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NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS

OF THE

FOURTH MEETING

OF THE

EXECUTIVE

OF THE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

OTTAWA

1 MARCH, 1948

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Initial Distribution

Proceedings of the Fourth Meeting

of the

EXECUTIVE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in Room 2121, National Research Building

9:30 A.M., 1 March, 1948.

---

1. Attendance

Dr. R. G. Ellis, Chairman
Pres. C. J. Mackenzie
Dr. H. K. Brown
Dr. E. Charron
Col. E. M. Wansbrough

Mr. S. J. Cook, Secretary

2. Chairman's Remarks

THE CHAIRMAN said that a certain amount of business transacted at the Sixth Meeting of the Associate Committee on Dental Research had been referred to the Executive for consideration and report. These items would be dealt with at this Meeting.

Business Arising Out of the Minutes of the Sixth Meeting of the Associate Committee on Dental Research.

3. Tropicalization Report (Min. 5(i) and App. "P", 6th Mtg.)

THE CHAIRMAN said that he had read Dr. Coons' report and had found that it contained much material from other sources than the Canadian Dental Corps. Many of the references indicated that numerous items were not affected by tropical conditions and he doubted that it would be necessary to give Dr. Coons' summary any wider circulation than could be secured through its inclusion in the proceedings.

After some discussion the Executive agreed to recommend that separate copies of the report published in Appendix "P" of the Proceedings of the Sixth Meeting be prepared for distribution on request and that a news item regarding the availability of this report be sent to the Journal of the Canadian Dental Association, Oral Health and the Journal of the Ontario Dental Association but that the report be not published in any other form.

4. Paper by Dr. Tickle (Min. 5(ii), 6th Mtg.)

THE SECRETARY reported that the paper submitted by Dr. Tickle for publication in the Canadian Journal of Research had been forwarded by the Chief Editor to two section editors for review and had subsequently been returned to the author with suggestions for its revision.

5. Revision of Project DR 4 (Min. 7(iv), 6th Mtg.)

THE CHAIRMAN reported that as requested he had consulted individually with Doctors Best, Box and Linghorne, and that it had been decided as a result of these conversations to request a final report on DR 4 at the March 1948 meeting of the Committee at which time a new application would be submitted dealing with other phases of this research problem.

6. Publication of Report on Denture Base Materials (Min. 7(v), 6th Mtg.)

THE CHAIRMAN reported that he had received two copies of Dr. Westman's paper for submission to the Executive as the Publications Panel of the Committee but that unfortunately he had left these two copies in his office in Toronto. He recalled that it had been suggested at an earlier meeting that the paper might be of interest to the Journal of the Canadian Dental Association or that perhaps the Canadian Dental Foundation might like to publish it as a bulletin. He had promised to make inquiries in this connection and would still do so.

7. Terms of Reference (Min. 9, 6th Mtg.)

THE EXECUTIVE gave careful consideration to the drafting of terms of reference along the lines suggested by the National Research Council, and now recommends the adoption of the revised terms of reference as shown in Appendix "A".

8. Paper by Dr. D. F. Stedman (Min. 11(iii), 6th Mtg.)

COL. WANSBROUGH reported that a paper by Dr. Stedman jointly with the Canadian Dental Corps, on the method of treatment for trench mouth developed during the war, had been sent to the Journal of the Canadian Dental Association for publication.

The Executive AGREED to recommend that, if the paper is published, the Committee purchase 100 reprints.

Applications for Grants-in-Aid

9. Applications for grants-in-aid for 1948-49 were reviewed and action was recommended as indicated:

RENEWALS

	Grant No.	Grantee	Grant Recommended $
(i)	DR 1	Dr. J. J. Rae	1760.
(ii)	DR 2	Dr. G.H.W. Lucas	1200.
(iii)	DR 3	Dr. H. K. Box	300.
(iv)	DR 9	Drs.O.J. Walker and H. R. MacLean	1100.
(v)	DR 11	Dr. R. J. Godfrey	2200.
(vi)	DR 12) DR 21)	Dr. A.E.R. Westman	5000.
(vii)	DR 13	Dr. M. Doreen Smith	1455.
(viii)	DR 14	Dr. M. Doreen Smith	1500.
(ix)	DR 15	Dr. Norma Ford Walker	3000.
(x)	DR 16	Dr. C. H. Best	1500.
(xi)	DR 17	Dr. R. F. Shaner	1000.
(xii)	DR 18	Dr. H. K. Box	1620.
(xiii)	DR 19	Dr. E. A. Sellers (subject to review)	1575.
(xiv)	DR 20	Dr. Jules Thébaud	750.
(xv)	DR 21	Dr. A.E.R. Westman (See DR 12)	

NEW APPLICATIONS

(xvi)	DR 22	Dr. H. K. Box	2200.
(xvii)	DR	Dr. C.P. Leblond - This application was for $3000. to study the "Entry of phosphate and carbonate salts into teeth as shown with the help of radio-phosphorus and radio-carbon". It was decided that this application should be studied further and reviewed by the Main Committee.	

NEW APPLICATIONS (cont'd)

(xviii) DR — Dr. L. F. Bélanger -
This application was for $2800. for a study of the "Mechanism of bone and tooth formation as revealed with radioactive phosphorus".

On consideration the Executive was of the opinion that this application was medical rather than dental in character and might be referred to the Advisory Committee of the Division of Medical Research for consideration.

10. Recommendations

THE EXECUTIVE recommended :

(i) That the grants listed above, except DR 19, be approved;

(ii) That DR 19 be further considered;

(iii) That the application from Dr. Leblond be given further study;

(iv) That the application from Dr. L. F. Bélanger be referred to the Advisory Committee of the Division of Medical Research for consideration.

The total amount of the grants for which recommendations were made was $26,160. The funds available for grants in 1948-49 amount to $27,500.

11. Fellowships (Min. 10, 6th Mtg.)

A memorandum by Dr. D. L. Thomson on the subject of Fellowships was considered. It was decided to recommend that two grades of Fellowships be provided, on the same basis as the Fellowships offered by the Advisory Committee of the Division of Medical Research namely (i) Senior Fellowships of a value of $1500. - $2400. ; (ii) Junior Fellowships, $1000. - $1200. per annum.

12. Membership of the Committee

The Executive recommends that this year and next the Committee membership be reduced by one each year, in order to restore the distribution of membership, by professions, in the Committee to the basis agreed upon when the Committee was

formed, namely eight members representing the basic sciences, two ex officio dental representatives from Government departments (i.e. one each from the Royal Canadian Dental Corps and the Department of National Health and Welfare), and six members representing the dental profession generally. The membership of the Committee was increased by two, by virtue of the fact that two Dental Corps representatives were retained on the Committee when they returned to civilian life. The President of the National Research Council is ex officio a member of the Committee and the Secretary also is an appointee of the National Research Council.

The Executive recommended that the following changes in membership for 1948-49 be forwarded to the National Research Council for consideration and confirmation, if approved:-

(i) That the appointments of the following members be renewed for a three-year term 1 April 1948 - 31 March 1951:

Dr. R. G. Ellis
Dr. E. Charron
Dr. O. W. Ellis
Dr. J. K. W. Ferguson

(ii) That no appointment be made in succession to Dr. W. J. Linghorne, in order to restore the original balance of membership in the Committee;

(iii) That the resignation of Dr. G. D. Stibbs be accepted as of 31 March 1948, since he is leaving Canada to accept a new post, and that Dr. R. H. McDougall be appointed for one year, 1 April 1948 - 31 March 1949 to complete the unexpired portion of Dr. Stibbs' appointment;

(iv) That, at his express request, Dr. D. Mainland be not re-appointed.

The Meeting adjourned at 5 P.M.

APPENDIX "A"

NATIONAL RESEARCH COUNCIL

Basic Terms of Reference for Committees

In these terms of reference, the word
"field" shall mean the field of dental science
"Committee" shall mean the Associate Committee on Dental Research
"Chairman" shall mean the Chairman of the Committee
"Secretary" shall mean the Secretary of the Committee
"Council" shall mean the National Research Council
"President" shall mean the President of the National Research Council
"General Secretary" shall mean the General Secretary of the National Research Council.

The Associate Committee on Dental Research is hereby assigned the following terms of reference.

1. To further research work in Canada in the assigned field.

2. To serve in a liaison capacity between the Council and governmental, educational and other organizations or agencies engaged in, or concerned with research in the assigned field.

3. To investigate and review when necessary the facilities which exist in Canada for research in the assigned field.

4. To prepare when necessary a list of specific projects in the field on which research should be undertaken in Canada.

5. To prepare and submit to the Council prior to 1 October each year an estimate of its total financial requirements(including subcommittees) for the fiscal year beginning 1 April following.

6. Within the limits of the funds allotted to the Committee each year, to award grants in aid of specific research projects to persons competent to direct such projects, and who have suitable facilities at their disposal. All such awards are to be reported immediately to the General Secretary for the information of the Standing Committee on Assisted Researches.

7. To secure from the director of each project an annual report and such other reports as the Council may require, review such reports and pass them to the Director of Information Services not later than dates to be specified.

8. To make recommendations to the National Research Council on any question within these terms of reference, when in the judgment of the Committee this is desirable or necessary.

9. The Committee, subject to the approval of the President, may appoint subcommittees for the more effective prosecution of its work. The Committee shall submit specific terms of reference for each subcommittee which it proposes to appoint and shall appoint its members, its Chairman and its Secretary.

Following the appointment of a subcommittee, the Committee shall inform the General Secretary promptly, and shall furnish him with a copy of the terms of reference and a list of the members and the officers of the subcommittee and of any changes therein which are authorized from time to time.

No classified information shall be disclosed to the officers or members of a subcommittee unless and until the General Secretary has been formally advised of the intention to do so and the Committee has received written advice that the President approves the proposed action.

10. The Committee shall appoint annually an Executive consisting of the Chairman, the Secretary and three members of the Committee. The duties of the Executive shall be (i) to deal with matters of an emergency character; (ii) to bring in recommendations concerning financial aspects of the Committee's business; (iii) to review papers submitted for publication, and (iv) to deal with any other matters pertaining to administration. Notices of meetings of the Executive and copies of its proceedings shall be sent to all members of the Committee. Members of the Committee who are available at the time and place of any Executive meeting are invited to attend.

11. The Committee shall prepare and submit to the President of the National Research Council on or before 28 February each year, a report covering the activities of the Committee during the preceding calendar year and shall attach thereto a list of the members and the officers of the Committee and of each subcommittee in existence on the said date.

INITIAL DISTRIBUTION

		Term to Expire
* 1.	Dr. R. G. Ellis, Chairman	31 March, 1948
2.	President C. J. Mackenzie (ex officio)	--
	Rep. Dental Profession	
3.	Dr. H. K. Box	31 March, 1949
* 4.	Dr. E. Charron	31 March, 1948
5.	Dr. D. S. Coons	31 March, 1949
6.	Dr. M. H. Garvin	31 March, 1950
7.	Dr. W. J. Linghorne	31 March, 1948
8.	Dr. H. R. MacLean	31 March, 1950
9.	Dr. G. D. Stibbs	31 March, 1949
	Rep. Army Dental Corps	
* 10.	Col. E. M. Wansbrough (ex officio)	--
	Rep. Division of Dental Health Dept. Nat. Health and Welfare	
11.	Dr. H. K. Brown (ex officio)	--
	Rep. Basic and Med. Sciences	
12.	Dr. C. H. Best	31 March, 1950
13.	Dr. E. F. Burton	31 March, 1949
14.	Dr. J. B. Collip	31 March, 1949
15.	Dr. O. W. Ellis	31 March, 1948
16.	Dr. J. K. W. Ferguson	31 March, 1948
17.	Dr. D. Mainland	31 March, 1948
18.	Dr. J. J. Rae	31 March, 1950
* 19.	Dr. D. L. Thomson	31 March, 1950
20.	Mr. S. J. Cook, Secretary	--
21.	Office Copy (General Secretary)	--
22.	Board Room Copy	
23	Library	
24-33	Reserve	

* Members of the Executive.

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FACULTY OF DENTISTRY
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COPY NO. 1

NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS

OF THE

SEVENTH MEETING

OF THE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

OTTAWA

2 MARCH, 1948

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Appendix "B" Investigation of repair techniques for methacrylate dentures by A.E.R. Westman.

Appendix "C" A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of dental arches, by Norma Ford Walker.

Appendix "D" A study of micro organisms found in deep periodontal pockets and caries lesion as revealed by the electron microscope by H. K. Box.

Appendix "E" Research on denture base materials and denture preparations by A.E.R. Westman.

Appendix "F" The development of culture technique for certain fungus-like organisms found in periodontal disease by C. H. Best.

Appendix "G" The experimental production of dental caries in vitro by H.K. Box and R.A. Hugill.

Appendix "H" An anatomical, histological and physiological study of the role of the condyle in mastication by Charles H. Moses.

Appendix "I" An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry by Drs. O. J. Walker and H. R. MacLean.

Appendix "J" An investigation of the effects of solutions used in operative dentistry on the vital pulps of teeth by R. F. Shaner.

Appendix "K" Improvement of sub-gingival curettage and surgical techniques used in the treatment of "pyorrhea alveolaris", by Jules Thébaud.

Appendix "L" An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides, by J.J. Rae.

Appendix "M" Chemical study of nitrous oxide for dental anaesthesia by G.H.W. Lucas.

Appendix "N" Observations on the systemic and local tissue toxicity of eight local anaesthetics by H. S. Hamilton and E. A. Sellers.

Appendix "O" A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario, by M.Doreen Smith.

Appendix "P" Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries, M. Doreen Smith.

Appendix "Q" Investigation and critical report on dental caries research by J. S. Bagnall.

Appendix "R" To study the effects of altitude acceleration and deceleration on oral tissues, by E.M.Wansbrough.

Appendix "S" A study of the use of periodontal cement packs in the prevention and treatment of disease of the supporting tissues of the teeth, by W. J. Linghorne.

Appendix "T" Letter of March 13, 1948 from Dr. R. G. Ellis, to the National Research Council.

Initial Distribution.

NATIONAL RESEARCH COUNCIL

Proceedings

of the

SEVENTH MEETING

of the

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in Room 2121, National Research Building

9:30 a.m., 2 March, 1948

---

1. Attendance

Dr. R. G. Ellis, Chairman
Pres. C. J. Mackenzie
Dr. H. K. Box
Dr. H. K. Brown
Dr. E. Charron
Dr. J. B. Collip
Dr. O. W. Ellis
Dr. J. K. W. Ferguson
Dr. W. J. Linghorne
Dr. J. J. Rae
Dr. G. D. Stibbs
Dr. D. L. Thomson
Col. E. M. Wansbrough

Mr. S. J. Cook, Secretary

By Invitation

Dr. J. S. Bagnall
Dr. M. Doreen Smith
Dr. Norma Ford Walker

Apologies for their absence were received from Dr. C. H. Best, Dr. D. S. Coons, Dr. M. H. Garvin, Dr. D. Mainland, and Dr. H. R. MacLean.

2. Chairman's Remarks

THE CHAIRMAN welcomed Dr. Bagnall, Dr. Smith and Dr. Walker, grantees under the Committee, who had been invited to present their reports in person at this Meeting. He said that the

Fourth Meeting of the Executive had been held on the preceding day to consider business arising out of the Minutes of the Sixth Meeting of the Committee and new business that should be brought before this Meeting.

3. Minutes of the Sixth Meeting

It was MOVED by Dr. Ferguson and SECONDED by Dr. Stibbs:

That the Minutes of the Sixth Meeting of the Committee, having been circulated, be taken as read and approved. CARRIED.

4. Minutes of the Fourth Executive

It was MOVED by Dr. Linghorne and SECONDED by Dr. Rae:

That the Minutes of the Fourth Meeting of the Executive as read by the Secretary be approved. CARRIED.

5. Paper on Denture Base Materials (Min. 6, 4th Exec.)

It was MOVED by Dr. Ferguson and SECONDED by Dr. Collip:

That the manuscript on Denture Base Materials submitted to the Chairman by Dr. A. E. R. Westman be referred back to the authors with approval of the manuscript for publication and that they be authorized to submit it to any journals of their choice. CARRIED.

Reports of Grantees

6. DR 1 - Dr. J. J. Rae

"An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides"

DR. RAE presented a summary and his complete report both of which appear in full in APPENDIX "L"

THE CHAIRMAN said that it was encouraging to note that two papers had resulted from this project.

7. DR 2 - Dr. G. H. W. Lucas

"Chemical study of nitrous oxide for dental anaesthesia"

Tickle paper

DR. FERGUSON presented a summary of the work done by Dr.Tickle under the direction of Dr. Lucas which appears in full in APPENDIX "M"

He said that this subject matter reported on the part of the project dealing with "A comparison of the gas percentage delivery and percentage dial setting in anaesthetic gas machines". It had also been placed on the agenda for discussion at the annual meeting of the Canadian Anaesthetists which is to be held in Toronto in March 1948 when he hoped a decision might be reached as to the procedure which should be followed in dealing with this problem.

8. DR 3 - Dr. H. K. Box

"A study of micro organisms found in deep periodontal pockets and caries lesion as revealed by the electron microscope"

DR. BOX summarized his report which appears in full in APPENDIX "D"

9. DR 4- Dr. H. K. Box

"A study of the use of periodontal cement packs in the prevention and treatment of disease of the supporting tissues of the teeth"

THE CHAIRMAN reported that as noted in Min. 5, 4th Exec., a Conference had been held at which it was agreed that a final report on DR 4 should be presented at this Meeting and that a new application for a grant on a related subject would also be submitted for consideration. He asked Dr.Linghorne to present the final report on DR 4.

DR. LINGHORNE said that work had been completed and a rough draft of the report had been prepared but that it would have to be reviewed by Dr. Best and Dr. Box before it could be presented in final form. A draft of a paper for publication on this subject had also been prepared and would be submitted as soon as it had been reviewed by Dr. Best and Dr. Box. Both the report and the paper would be available shortly. He then presented a brief summary on this subject which appears in full in APPENDIX "S"

THE CHAIRMAN stated that both the report and the paper should be available before the next meeting of the Committee.

10. DR 5 - Dr. A. E. R. Westman

"Research on denture base materials and denture preparations"

THE CHAIRMAN recalled that he had reported to the Executive (Min. 6, 4th Mtg.Exec.) on this subject and that at this Meeting (see Min. 5) a decision had been taken in the matter. Dr. Westman's summary appears in full in APPENDIX "E"

11. DR 6 - Col. E. M. Wansbrough

"To study the effects of altitude acceleration and deceleration on oral tissues"

COL. WANSBROUGH presented a brief report which appears in full in APPENDIX "R"

12. DR 7 - Dr. J. S. Bagnall

"Investigation and critical report on dental caries research"

DR. BAGNALL presented a summary report which appears in full in APPENDIX "Q"

He showed two volumes of the report which he has had under preparation and said that he thought it would be necessary to supplement the Bibliography by a report in which the material in the Bibliography would be referred to under subject headings.

THE CHAIRMAN said that Dr. Bagnall had done a tremendous amount of work and that members of the Dental profession generally as well as members of the Committee were eagerly looking forward to the publication of Dr. Bagnall's report.

Several members expressed their concurrence in the tribute voiced by the Chairman regarding the great task performed by Dr. Bagnall and it was AGREED to record the high appreciation of the Committee of the work done by Dr. Bagnall and to express sincere thanks to him for having compiled this extensive and extremely useful bibliography.

13. DR 9 - Drs. O. J. Walker and H. R. MacLean

"An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry"

THE CHAIRMAN said that both a summary and a report on this project had been received. These both appear in full in APPENDIX "I"

It was noted in discussion that this research appears to be directed to a study of the effects of certain proprietary preparations on metals and alloys used in dentures. The question was raised as to whether the composition of these proprietary materials was sufficiently well known and it was suggested that perhaps a study of them should be conducted by some Government agency rather than under a grant from the Committee.

DR. O. W. ELLIS thought the investigators should also look for small percentages of carbon and other elements in their alloys as these would have a considerable effect on the resistance of the alloys to corrosion.

THE CHAIRMAN said that the American Dental Association has a Committee that studies materials on the market and publishes lists of products that are considered acceptable to the profession. This raised the question as to whether the Associate Committee on Dental Research should carry on similar work in Canada.

DR. RAE thought that corrosion tests on commercial alloys would not produce very helpful results especially when the composition of the commercial solutions with which they were being treated was also not very well known.

DR. O.W. ELLIS suggested that more useful results might be secured if work was concentrated on a group of samples of one alloy.

DR.STIBBS said the original idea was to determine whether cleaning agents on the market attack the metal alloys used in dentistry. The purpose was to determine the effect of the cleaning solutions. It was known that some cleaning agents actually deposit material on dentures.

DR. RAE noted again that there were two sets of variables in the problem and said that it would be better to confine the work to one alloy say stainless steel but he doubted that it was the function of the Committee to make analyses of cleansing agents. He suggested that perhaps the American Dental Association would do the necessary test work.

DR. FERGUSON thought the project was well worth while if the formulae of the solutions used could be secured from the manufacturers and suggested that the grantees be written to accordingly.

Luncheon adjournment 12:30 to 1:30

---

14. DR 10 - Dr. G. M. MacDonald

"Facial prostheses constructed of vinyl resins"

THE CHAIRMAN said that no report had been received from Dr. Macdonald although as noted in Min. 7, 9, of the Sixth Meeting he had promised a full report for this Meeting of the Committee. It was agreed that a request should be sent to Dr. Macdonald for a final report on this project.

15. DR 11 - Dr. R. J. Godfrey

"An anatomical, histological and physiological study of the role of the condyle in mastication"

THE CHAIRMAN said that a report on this project had been received. This report appears in full in APPENDIX "H"

He said that this project had been referred to Dr. H. Mortimer at McGill University and Dr. Watt at Toronto for consideration and both had reported favourably on it. The project was one dealing with a subject on which there had been much controversy. It was a very large project and in his opinion might well be divided into several smaller parts.

DR. STIBBS mentioned that he had heard some criticism of this subject from Western United States sources and he thought it might be useful to refer the question to a western referee as well as to eastern members for an opinion.

DR. BOX said that a large Committee was being established at Toronto to study this problem.

It was MOVED by Dr. Thomson and SECONDED by Dr. Linghorne:

That project DR 11 on the "Study of the role of the condyle in mastication be referred to the Executive with a request that a consultation be held with the grantee with the idea of reducing this wide general project to a series of specific studies on which progress might be expected in a reasonable time. CARRIED.

16. DR 12 - Dr. A. E. R. Westman

"Investigation of cements for methacrylate inlays"

THE CHAIRMAN reported that under the existing arrangement with the Ontario Research Foundation work was proceeding on projects DR 12 and DR 21 under a single grant. A brief summary of work under DR 12 appears in full in APPENDIX "A"

17. DR 13 - Dr. M. Doreen Smith

"A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario"

DR. M. DOREEN SMITH presented a summary and her complete report both of which appear in full in APPENDIX "O"

There was a brief discussion of this report regarding the media used and the relative labour involved in the proposed method as compared with the chemical method.

DR. SMITH said that the chemical method was very difficult to use while her proposed microbiological method would be relatively simple to use if it proved satisfactory. She hoped soon to publish a preliminary report on her work in order to have it mentioned in the literature.

THE CHAIRMAN said that Dr. Harry Brown was very much interested in this method because he hoped to make analyses of teeth of people from various places in Western Ontario in connection with his fluorine studies and he was looking for an easy method of determining the fluorine content of teeth.

18. DR 14 - Dr. M. Doreen Smith

"Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries.

DR. SMITH presented a summary and her complete report both of which appear in full in APPENDIX "P"

THE CHAIRMAN recalled that in Min. 7 (xiii), 6th Mtg., Dr. Thomson had pointed out that Dr. Smith's project DR 14 appeared to involve two problems (i) what is the fluorine content of the food intake of the populace; (ii) what is the relationship of the fluorine content of water and soil to the fluorine content

of foodstuffs grown in a given area ; and he pointed out that much of the food eaten in a fluorine-free area might be derived from other sections in which fluorine is present in the soil and water, and vice versa.

DR. THOMSON thought that Dr. Smith should be on the lookout for physiological studies on fluorine intake and excretion used to determine actual absorption of fluorine.

DR. SMITH said that when 4-5 p.p.m. of fluorine were present in the intake most of it was excreted.

THE CHAIRMAN thought it would be worthwhile to determine the fluorine content of spinach grown in back-yard gardens of Stratford and Brantford. Both the water soluble and the total fluorine should be determined.

DR. WALKER observed that the same kind of spinach should be grown in all gardens from which samples were taken as the fluorine content of different varieties of spinach might not be the same.

DR. RAE suggested that it would be necessary to correlate the fluorine analyses with the soil in which the spinach was grown.

DR. BROWN said that in his work he treated Sarnia as fluorine free and used Stratford and Brantford for his survey results.

19. DR 15- Dr. Norma Ford Walker

"Comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of dental arches"

THE CHAIRMAN welcomed Dr. Norma Ford Walker who had come to present her report in person.

DR. NORMA FORD WALKER submitted a summary and a full report with charts which she described in detail. These appear in full in APPENDIX "C"

DR. FERGUSON expressed his appreciation of the work reported by Dr. Walker and said that he hoped she would be encouraged to pursue this investigation, a statement which was greeted with applause.

20. DR 16 - Dr. C. H. Best

"The development of culture technique for certain fungus-like organisms found in periodontal disease"

DR. LINGHORNE presented a summary of the work done which appears in full in APPENDIX "F"

He said that it had not been found possible to culture the organisms artificially. Entering the pocket every day interferes with the growth of the organism. It was very difficult to study the life cycle.

DR. BOX thought it would be necessary to study the organisms in smears and efforts were being made to develop them.

21. DR 17 - Dr. R. F. Shaner

"An investigation of the effects of solutions used in operative dentistry on the vital pulps of teeth"

THE CHAIRMAN said that a summary of his work had been received from Dr. Shaner. This summary appears in full in APPENDIX "J" He drew the attention of the Committee to the fact that this summary is practically identical with that submitted by Dr. Shaner in October 1947 which appeared as Appendix "G", 6th Meeting. He said that later in the day an application for renewal of the grant for this work would be presented.

DR. STIBBS suggested that a letter be sent to the grantee pointing out that his February report was practically identical with the one submitted in October 1947.

On discussion it was agreed that this should be done and that funds should be encumbered in the amount of the grant requested but that a more complete report should be secured from the grantee before a new award is made and that the Executive be authorized to award the grant, when they are satisfied on the basis of a further report that the grant is warranted. AGREED.

22. DR 18 - Dr. H. K. Box

"The experimental production of dental caries in vitro"

DR. BOX presented a summary and a complete report as well as a reprint entitled "Concerning the Pathogenesis of Periodontal Disease" which had been published in The Journal of Periodontology January 1948. All three documents appear in full in APPENDIX "G"

DR. STIBBS complimented Dr. Box on the work he was doing in this field and the members expressed their concurrence in these views.

23. DR 19 - Dr. E. A. Sellers

"Tissue toxicity and efficiency of local anaesthetics for topical application and nerve block in dentistry"

DR. FERGUSON presented the summary and report prepared by Dr. Sellers. These appear in full in APPENDIX "N" He said there was great need for good scientific information on anaesthetics and reliable methods for their assessment. It was important to know the relative toxicity and efficiency of local anaesthetics.

24. DR 20 - Dr. Jules Thébaud

"Improvement of sub-gingival curettage and surgical techniques used in the treatment of pyorrhea alveolaris"

THE CHAIRMAN said that a comprehensive report had been received from Dr. Thébaud but as it had only been reproduced today he suggested that the report be referred to Dr. Box for an opinion and that the Executive be authorized to deal with the new application for a grant received from Dr. Thébaud in the light of the report made by Dr. Box. AGREED.

Dr. Thébaud's complete report appears in full in APPENDIX "K"

25. DR 21 - Dr. A. E. R. Westman

"Investigation of repair techniques for methacrylate dentures"

THE CHAIRMAN said that a summary report had been received from Dr. Westman and there had been three Interim Reports by Mr. Christie all of which appear in full in APPENDIX "B"

DR. O.W. ELLIS presented these reports and pointed out that future work under the project is outlined on page B-5 of report No. 4801, (one of the reports in Appendix "B").

26. Applications for Grants-in-Aid

(a) RENEWALS

The following applications for renewals of grants were approved in the amounts indicated:-

Grant No.	Grantee	Amount
		$
DR 1	Dr. J. J. Rae	1760.

Grant No.(cont'd)	Grantee	Amount $
DR 2	Dr. G.H.W. Lucas	1200.
DR 3	Dr. H. K. Box	300.
DR 9	Dr.O.J. Walker and Dr. H.R. MacLean	1100.
DR 11	Dr. R. J. Godfrey	2200.
DR 12) DR 21)	Dr. A.E.R. Westman	5000.
DR 13	Dr. M. Doreen Smith	1455.
DR 14	Dr. M. Doreen Smith	1500.
DR 15	Dr. Norma Ford Walker	3000.
DR 16	Dr. C. H. Best	1500. Excel
DR 17	Dr. R. F. Shaner (This grant was encumbered and the Executive was authorized to take the necessary action)	1000. (ENCUMBERED) *
DR 18	Dr. H. K. Box	1620.
DR 19	Dr. E. A. Sellers	1575.
DR 20	Dr. Jules Thébaud (Funds encumbered and Executive authorized to take necessary action after receipt of report by Dr. Box).	750. (ENCUMBERED) Excel
DR 21	Dr. A. E. R. Westman	(See DR 12)

(b) NEW APPLICATIONS

DR 22	Dr. H. K. Box An investigation of the mechanism of repair of the supporting structure of the teeth.	2200.

DR 23 Dr. C. P. Leblond
Entry of phosphate and carbonate salts into teeth as shown with the help of radio-phosphorus and radio-carbon.

This application was for $3,000. including $1200. for salaries and $1800. for materials. It was thought the amount required for materials was excessive and it was suggested that the grantee be asked to furnish a new application limiting the cost of materials to $1000. making a total of $2200. This amount was encumbered and the Executive was authorized to take the necessary action on receipt of a new application. (Motion by Dr. Linghorne and Dr. Stibbs). $2200. (ENCUMBERED)

Encd

27. Amount of Grants

Total amount voted	24,410.
Total amount encumbered	3,950.
TOTAL	28,360.

28. Terms of Reference

The revised Terms of Reference drawn up by the Executive were APPROVED. (See Appendix "A", 4th Exec.)

29. Fellowships

The recommendation of the Executive was accepted namely that two grades of Fellowships be provided on the same basis as the Fellowships offered by the Advisory Committee of the Division of Medical Research i.e. (i) Senior Fellowships of a value of $1500. - $2400.; (ii) Junior Fellowships $1000. - $1200. per annum.

It was MOVED by Dr. Ferguson and SECONDED by Dr. Linghorne:

That the Chairman be authorized to prepare revised regulations for the award of dental Fellowships upon a similar basis to the regulations drawn for Medical Fellowships and further authorized to submit these regulations to the National Research Council with a request for their approval and that the two classes of Fellowships recommended by the Committee also be submitted for approval. CARRIED.

The Chairman's letter to the National Research Council recommending the establishment of Fellowships appears in APPENDIX "T"

30. Correspondence

(i) THE CHAIRMAN presented a letter from D. Mainland dated 2 February 1948, reading in part as follows:

" With this meeting my term of three years on the Committee is completed, and I should like to say how very much interested I have been in the meetings, and how much I appreciate the friendships formed with other members of the Committee.

" In some committees of the Council, members who have reached the end of their first three years are often re-elected for another three. I do not know whether such a practice is contemplated in the Dental Committee, but if it were considered in my own case I should, very regretfully, ask to be allowed to resign. I find that I cannot do justice to the various activities that I have undertaken, and I believe that on the Dental Research Committee I should now make way for someone who can not only devote more attention to its work but who has more of the special knowledge of the field.

" Whether I retire automatically or by resignation I shall, of course, always be very much interested in the work of the Committee, and if I could be of help, for instance, by refereeing of applications that might fall within my field, I should be very glad of the opportunity."

(ii) The following letter dated 27 February from Dr. Stibbs was read:

" I will shortly be retiring from practice in Vancouver, to accept a post with the University of Washington in Seattle, Washington. I must, therefore, herewith tender my resignation from membership on the Associate Committee for Dental Research.

" In doing so, may I suggest that the Committee consider recommending to the National Research Council, the appointment of Dr. R. H. McDougall, to fill my unexpired term.

" Dr. McDougall, of 1505 Hampshire Road, Victoria, B.C., would be very acceptable to the members of the profession in B.C., and would bring to his appointment enthusiasm, sincerity and ability.

" May I express through you to the President of the National Research Council, and to the Chairman and members of the Associate Committee on Dental Research, my appreciation of the privilege of having served on the Committee. I would like, also to extend my best wishes for continued development and progress of dental research in Canada through the very fine attitude and support of the National Research Council."

THE CHAIRMAN expressed the regret of the Committee that these two members found it impossible to continue their association with the Committee. He offered Dr. Stibbs the best wishes of the Committee in his new post and said that all members appreciated highly the time that Dr. Stibbs had given to Committee activities. Dr. Mainland's wise counsel would also be greatly missed around the Committee table.

31. Recommendations for Membership

The recommendations regarding changes in the membership of the Committee agreed upon by the Executive (Min. 12, 4th Exec.) were APPROVED.

It was MOVED by Dr. Ferguson and SECONDED by Dr. Rae:

That Dr. C. B. Stewart of Dalhousie University be recommended for membership in the Committee for a three-year term 1 April 1948 - 31 March 1951, in succession to Dr. Mainland;

and

That Dr. R. H. McDougall of 1505 Hampshire Road, Victoria, B.C., be nominated for one year 1 April 1948 - 31 March 1949 to complete the unexpired portion of Dr. Stibbs' appointment.

32. Appointment of Executive, 1948-49

THE CHAIRMAN said that according to the Terms of Reference agreed upon for the Committee the Executive had to be appointed annually.

It was MOVED by Dr. Ferguson and SECONDED by Dr. Linghorne:

That the Executive for 1948-49 consist of the

Chairman and the Secretary and Drs. Charron, Thomson, and Wansbrough. CARRIED.

33. Date of Next Meeting

It was AGREED that the next meeting of the Committee should be held at the call of the Chair probably in October, 1948.

The Meeting adjourned at 5:30 P.M.

APPENDIX "A"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Investigation of cements for methacrylate inlays.

Grantee: Dr. A.E.R. Westman

Project No.: DR 12 Amount of Grant: (Included in DR 5 total $5,000)

SUMMARY OF WORK

Work on this project has been subordinated to that on Project DR 21. Some of the findings on the latter project may have a direct bearing on DR 12, inasmuch as they have led to the possibility of the rapid polymerization of methyl methacrylate at low temperatures. With the aid of light, particularly ultra-violet radiations, and/or the use of special catalysts it may be feasible to make direct acrylic inlays or to use methyl methacrylate as a cement.

February,
1 9 4 8.

APPENDIX "A"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Investigation of cements for methacrylate inlays.

Grantee: Dr. A.E.W. Wesson

Project No.: DR 12 Amount of Grant: (Included in DR 5 total $5,000)

SUMMARY OF WORK

Work on this project has been subordinated to that on Project DR 21. Some of the findings on the latter project may have a direct bearing on DR 12, inasmuch as they have led to the possibility of the rapid polymerization of methyl methacrylate at low temperatures. With the aid of light, particularly ultra-violet radiations, and/or the use of special catalysts it may be feasible to make direct acrylic inlays or to use methyl methacrylate as a cement.

February,
1942.

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION
(DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship
Report No. 4706 - DR-12

by

D. R. Christie

Work on this project is being subordinated to that on the problem of the repair of dentures.

Consideration is, however, being given to all phases of the problem such as methods of application of a synthetic resin cement, means of heating the cement or the inlay, the temperature tolerance of vital teeth and the type of resin cement best suited for the purpose.

November 13, 1947.

APPENDIX "B"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Investigation of repair techniques for methacrylate dentures.

Grantee: Dr. A.E.R. Westman

Project No. DR 21 (To be included in $5,000 awarded for DR 5 and DR 12)

SUMMARY OF WORK

Regular monthly progress reports on this project have been submitted to the Associate Committee. The work on this problem has been concerned with the development of a suitable repair technique for methacrylate dentures.

It was found that the presently accepted repair method of recuring dentures at 160°F. for 8 to 9 hours caused dimensional changes in dentures amounting to about 1/2 of 1 per cent. Repairing up to the temperature of boiling water caused distortions of more than 1 per cent. These changes were large enough to change the adaptation of dentures to casts of their bearing surfaces to change the occlusion of the teeth.

The influence of polymer powder particle size on the distortion of dentures was investigated and it was found that no difference in behaviour existed between dentures made with coarse polymer powder and dentures made with fine powder.

Since it is important in repairing to avoid high or even moderate temperatures, a low-temperature method was necessary. A temperature of 135°F. was found to be suitable to prevent distortion. Investigations were made varying the repairing time and the polymerization catalysts. Several organic peroxides, such as benzoyl peroxide and tertiary-butyl perbenzoate, were used as catalysts and the use of methyl methacrylate monomer from which the stabilizer, hydroquinone, was removed was also studied.

At first it was hoped that the suitability of the repairing method could be determined by curing plates of denture base material and then taking their Knoop hardness values. The variability of the hardness value, however, necessitated the use of the transverse strength as a criterion of satisfactory cure. There appeared to be no direct relation between

APPENDIX "B"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Investigation of repair techniques for methacrylate dentures.

Grantee: Dr. A.M.R. Weetman

Project No. DR 21 (To be included in $5,000 awarded for DR 5 and DR 12)

SUMMARY OF WORK

Regular monthly progress reports on this project have been submitted to the Associate Committee. The work on this problem has been concerned with the development of a suitable repair technique for methacrylate dentures.

It was found that the presently accepted repair method of reuniting dentures at 150°F. for 6 to 9 hours caused dimensional changes in denture according to about 1/2 of 1 per cent. Repairing up to the temperature of boiling water caused distortions of more than 1 per cent. These changes were large enough to change the adaptation of dentures to oasis of their bearing surfaces to change the occlusion of the teeth.

The influence of polymer powder particle size on the distortion of dentures was investigated and it was found that no difference in behaviour existed between denture resin made with coarse polymer powder and dentures made with fine powder.

Since it is important in repairing to avoid high or even moderate temperatures, a low-temperature method was necessary. A temperature of 150°F. was found to be suitable to prevent distortion. Investigations were made varying the repairing time and the polymerization catalysts. Several organic peroxides, such as benzoyl peroxide and tertiary-butyl perbenzoate, were used as catalysts and the use of methyl methacrylate monomer from which the stabilizer, hydroquinone, was removed was also studied.

At first it was hoped that the suitability of the repairing method could be determined by curing plates of denture base material and then testing their Knoop hardness values. The variability of the hardness value, however, necessitated the use of the transverse strength as a criterion of satisfactory cure. There appeared to be no direct relation between

transverse strength and Knoop hardness but the material with adequate strength and the highest hardness value was judged to be the most suitable.

On this basis, the best material was prepared by using polymer powder as supplied commercially with monomer from which the hydroquinone had been removed together with 0.1 per cent benzoyl peroxide (based on the weight of the monomer). Hydroquinone can be easily removed by simple distillation or by oxidation with aqueous sodium hydroxide solution followed by drying with chemical drying agents.

The usual monomer-polymer powder mixture was made and was cured by heating at 135°F. for 16 hours in a plaster mold. This curing period cannot be reduced materially but can conveniently be carried out over night.

At the present time experimental dentures are being repaired by this method to obtain additional confirmation of the above-mentioned results. The use of ultra-violet light to polymerize methyl methacrylate is also being investigated and it may be possible to effect a substantial reduction in curing time by the combination of a short heat treatment and subsequent ultra-violet irradiation. It has been reported that, in Germany during the war, a special catalyst, trihexylamine, was used for the rapid polymerization of methyl methacrylate. With this amine, it is said that direct acrylic inlays could be made in 15 minutes. We have been promised a research sample of this material and will investigate its use. If satisfactory, it could have an important bearing on the problems of this project as well as on DR 12.

February,
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February,
1944.

APPENDIX "B"

ONTARIO RESEARCH FOUNDATION
(DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship
Report No. 4701 - DR-21

by

D. R. Christie

Scope of This Report

The subject of this investigation is the repair of dentures. More specifically, it is concerned with the prevention of warpage or distortion of dentures which have to be repaired. Some experiments have been made on curing methyl methacrylate at low temperatures where distortion is definitely avoided. Preliminary work has been done on determining some properties of dentures made with very fine and coarse polymer powders.

Curing at Low Temperatures

Distortion on repairs is caused by heating the dentures to temperatures used originally to process the denture. Several hours at 160°F. is sufficient to cause a slight distortion, while more severe conditions such as heating at 212°F. for very short intervals of time will cause very serious dimensional changes.

First experiments here were based on curing flat plates of methyl methacrylate measuring 3 x 40 x 65 mm. in a plaster investment in a regular dental flask. A thermostatically-controlled air oven was used to heat the specimens but after 24 hours at this low temperature they were obviously incompletely cured. A higher temperature of 135°F. was investigated. Two dentures were "repaired" at this temperature and no evidence of distortion was apparent after 24 hours.

An indication of the degree of polymerization can be obtained by measuring the hardness of the specimens. The procedure employed here is to cure the plates for 24 hours, condition them for 2 days in water at room temperature, polish them and determine the Knoop hardness value. The standard hardness of a specimen cured by the thermoduct method of processing, as described in reports on Project DR-5, was determined to be 16.5. The purpose of these low-temperature cures is to produce a specimen approximating this value in hardness. The toughness of these specimens, as revealed by the A.D.A. test for transverse strength, may show that specimens failing to meet the value of 16.5, may be adequately strong. Future investigations will also look into this property.

Consistent hardness values could not be obtained using the air oven and it was necessary to use a water-bath to get reproduceable results.

Experimental Results

Specimens were cured at 135°F. in a water-bath for 24 hours. A standard was processed by the heating cycle of the thermoduct method. Specimens were also made from Lucitone monomer and polymer as supplied. For further experiments, inhibitor-free monomer was prepared by removing the hydroquinone stabilizer from a commercial grade of methyl methacrylate. This was done by shaking the monomer with dilute sodium hydroxide, washing 3 times with distilled water and drying over anhydrous calcium sulphate.

Specimen (monomer containing)	No. of Specimens	Knoop Hardness for Cures at 135° F. for 24 hrs.
Lucitone	1	14
0.001% Hydroquinone	2	13.4

Benzoyl Peroxide Series

Benzoyl peroxide is a well-known catalyst for the polymerization of methyl methacrylate. Large quantities of this catalyst produce low molecular weight polymers. This series was made to find the optimum amount of benzoyl peroxide to add to inhibitor-free monomer to produce the hardest specimen.

Specimen (% peroxide in monomer)	No. of Specimens	Knoop Hardness
0.0	1	14
0.1	4	14.8
0.2	1	13
0.3	1	14

A concentration of 0.1% benzoyl peroxide, based on the weight of the monomer, gave the hardest specimens. The hardness values obtained were very consistent. Since only one specimen of each of the other runs was made, the values are reported only to the nearest integral number.

Peroxide-Cobalt Naphthenate Series

In the polymerization of some unsaturated resins, it has been found that the addition of a metallic drier, such as cobalt

naphthenate, increases the rate of polymerization. Usually very small quantities of cobalt are required. We investigated the use of Nuodex Cobalt Drier, which contains 6% cobalt as the metal, in conjunction with benzoyl peroxide. We studied only the ultimate hardness values and made no study of the rate of polymerization.

The results of these tests are shown in the following table. Percentages are based on the weight of the monomer. Only one sample was cured at 135°F. for 24 hours.

Peroxide Content	Hardness Value — % Cobalt Metal in Monomer			
	0.01	0.0075	0.005	0.0025
0.1% Benzoyl Peroxide	15	14	15	
0.2% " "	--	15	15	14

No outstanding increase in the hardness values was produced by using this combination of catalyst and promoter. The amount of cobalt naphthenate necessary to give 0.01% cobalt metal causes a slight blue coloration of the normally pink denture material.

Other Peroxides

Many new peroxides have recently become available for the synthetic resin industry. We have obtained samples of several which are claimed to be effective in many cases. In addition, new promoters or accelerators which increase the rate of peroxide decomposition by an oxidation-reduction reaction are also available. A study of some has been started and we will investigate others in future experiments.

Size of Polymer Particles and Distortion

The idea has been suggested that dentures made of very fine polymer particles would show less distortion on repairing than dentures made of coarse particles. The theory is that large polymer particles will be distorted on packing and pressure on the dental flask to a greater extent than smaller particles. When the denture is heated on repairing, the large particles will tend to return to their original shape by reason of the so-called elastic memory, producing more distortion than would occur in the case of very small particles.

Some experiments are now being made to test this idea but nothing can be reported to date.

Programme of Future Research

1. Determine the transverse strengths of some specimens cured at 135°F.

2. Continue the investigation of peroxide catalysts and accelerators and their effect on the degree of polymerization. In this connection, some consideration might also be given to the rate of polymerization or, in other words, to the possibility of reducing the time required to produce a satisfactoty polymer.

3. Investigate some properties of dentures made from very fine and from coarse polymer particles.

November 13, 1947.

APPENDIX "B"

ONTARIO RESEARCH FOUNDATION
(DEPARTMENT OF CHEMISTRY)

Dental Materials Research Fellowship
Report No. 4702 - DR-21

by

D. R. Christie

Scope of this Report

Further experiments on curing methyl methacrylate at low temperatures are described in this report. The effects of cure time, catalysts and weathering on the hardness and the transverse strength of the denture base materials are discussed. The distortion on repair of dentures made with fine and with coarse polymer particles has been given some attention.

Polymer Particle Size and Distortion

The study of distortion on repair of dentures made with fine and coarse polymer powder was based on the theory that dentures containing fine polymer would suffer less warpage on repair than dentures containing coarse polymer particles.

Two denture blanks were made with methyl methacrylate monomer and 80-mesh or finer methyl methacrylate polymer. Also, two blanks were made with commercial polymer particles retained on an 80-mesh screen. These four dentures were cured by the thermoduct method.

After polymerization, the dentures were conditioned in water at room temperature for at least two days. Models or casts were then made against the tissue surfaces and gauge marks were scratched on the ridges and flanges and the distances between then measured on a travelling microscope.

Two dentures were invested in plaster in the usual manner for repairing and heated at 160° F. for 6 hours. They were deflasked and measured, re-invested and heated slowly from room temperature to 212° F. in 2½ hours. They were cooled, deflasked and measured again. The other two dentures were heated slowly to 212° F. and also measured.

The changes in dimensions caused by these repairing conditions are shown in the following table.

Denture	Percentage Decrease in Dimensions			
	6 hr. at 160° F.		R. T. to 212° F.	
	Flange	Ridge	Flange	Ridge
Coarse No. 1	.16	.22	.64	.66
Coarse No. 2	-	-	.81	.44
Fine No. 1	.49	.43	.98	.86
Fine No. 2	-	-	.48	.88

The results for the Coarse No. 1 and Fine No. 1 indicate that the denture made of fine particles showed greater distortion at 160° F. and also at 212° F. The results for the No. 2 dentures are confusing. The coarse polymer denture showed about twice as much warpage across the flanges as did the fine polymer at 212° F. while the reverse is true for the change across the ridges. However, the important feature is not which denture showed more or less distortion than the other, but that both dentures showed significant changes even at 160° F. In all cases, after "repairing", the dentures did not fit their casts accurately because of these slight changes in dimensions. These experiments should be repeated to check their reproducibility.

Low-Temperature Polymerization

Further experiments have been made in polymerizing methyl methacrylate at 135° F. for 24 hours or less. In addition to the Knoop hardness values, the transverse strengths have also been determined according to the A. D. A. specification. It was suggested in the previous report that the strength of the denture base material might be a better criterion of the degree of cure than the Knoop hardness. This is borne out by experimental evidence which fails to show a direct relation between hardness and strength. In some cases, a softer material has a higher transverse strength than a harder material and vice versa.

The following table lists the experimental results obtained for methyl methacrylate cured at 135° F. In all cases, the polymer powder used was Lucitone. According to the A. D. A. specification, a satisfactorily strong material must have a

deflection of less than 2.6 mm. at a load of 4000 grams, a deflection between 3 and 8 mm. at 6000 grams and an average maximum load of at least 6000 grams.

Monomer Used	No. of Specimens	Catalyst Used	Cure Time at 135° F.	Knoop Hardness	Deflection at 4000 gm.	Deflection at 6000 gm.	Av. Max. Load
ucitone	3	-	24 hr.	13.8	2.53	6.09	6500
nhibitor-free	4	-	"	13.2	2.44	5.57	6700
"	4	0.1% benzoyl peroxide	"	14.5	2.54	5.95	6100(f)x
"	2	"	12 hr.	13.1	2.87	8.96	6000(f)
"	3	0.1% t-butyl perbenzoate + 0.1% Accelerator 1000	"	12.6	2.54	5.89	5800(f)

(f) - fails to pass test.

x - this material fails because 2 of the 4 specimens did not withstand a load of 6000 grams.

This data reveals several important facts.

(1) There appears to be no obvious relation between hardness and transverse strength.

(2) Twelve hours is insufficient time for an adequate cure under these conditions.

(3) The combination of t-butyl perbenzoate and Accelerator 1000 is nearly as effective a catalyst over a 12-hour period as benzoyl peroxide is over a 24-hour period in producing a polymer of adequate strength. In the matter of hardness, it is not as effective and, as we indicated in the previous report on this subject, none of the special peroxide catalysts which we have tried causes any marked increase in hardness over benzoyl peroxide for comparable curing times.

(4) Several samples cured at 135° F. for 12 hours came close to passing the transverse strength test. This suggests that an over-night cure of approximately 16 hours at 135° F. may increase the strength to the point where the specifications may be met.

Effect of Weathering

It is well known that ultra-violet radiation in the region of 2500 to 3000 A. U. is an effective promoter of some types of polymerization reactions. This same range of the spectrum is also believed to be most effective in accelerated testing or weathering of protective coatings, for example.

A few specimens of methyl methacrylate were exposed to the radiations of a Weather-Ometer, an accelerated testing apparatus, for periods of 16 hours. The exposed surfaces of the specimens were then tested for hardness and the transverse strengths of two were determined.

Hardness

Monomer Used in Specimen	Catalyst Used	Cure Time at 135°F.	Original Hardness	Hardness After Exposure	Hardness Af 16 hr. in H
Inhibitor-free	t-butyl perbenzoate + Accelerator 1000	24 hr.	14.1	16.4	15.6
"	benzoyl peroxide	24 hr.	14.5	15.5	-
"	benzoyl peroxide	12 hr.	13.1	14.1	-
Inhibitor-free and Paraplex P-43[x] polyester resin	t-butyl perbenzoate + Accelerator 1000	24 hr.	14.9	17.4	15.7

[x] This resin is not an accepted denture base material and its application as such has not been developed

These data show that exposure to the Weather-Ometer radiations for 16 hours has produced a definite increase in the hardness. It is also interesting to note from the last column that there is a tendency for the hardness after exposure to fall off slightly after 16 hours conditioning in water to a value intermediate between it and the riginal hardness.

The intensity of the ultra-violet radiations from the Weather-Ometer is possibly not as high as could be obtained from other sources such as a mercury-vapor lamp. It is proposed to make a more elaborate study to determine the intensities of several sources and if possible to reduce the repair time by a considerable amount.

Transverse Strength

We have some evidence which suggests that ultra-violet radiation may also increase the transverse strength. In this regard, further experiments are necessary to give more conclusive results.

A test was made to learn if the above-described effects were actually due to radiation and not to a heat effect developed in the weathering apparatus. It was found that the temperature of a specimen would vary between 92° F. and 104° F., hardly enough to cause any increase in hardness or strength by continued polymerization. Furthermore, only the exposed faces of the specimens increased in hardness, while the unexposed faces remained the same.

Heat Effect of Grinding and Polishing

An experiment was made to ascertain whether grinding and polishing of specimens caused any variations in the surface hardness. A sample was processed against glass on both sides and the hardness determined on each side. Then one side was ground and polished in the same way that a denture is finished and the hardness redetermined. No difference was found. Grinding and polishing, therefore, does not affect the surface hardness.

Future Work

1. Continue experiments with coarse and fine polymer powders to obtain more conclusive information about distortion of dentures made with these materials.

2. Investigate further the influence of curing time at low temperatures on the transverse strength. Also, determine the transverse strength of material cured under accepted repair conditions.

3. Study some aspects of ultra-violet radiation on the polymerization of methyl methacrylate with the object of reducing the repair time to considerably less than 24 hours.

APPENDIX "B"

ONTARIO RESEARCH FOUNDATION
(DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship
Report No. 4801 - DR 21

by

D. R. Christie

Scope of This Report

This report presents additional information about distortion of dentures made with fine and coarse polymer powders when repaired by methods commonly used in practice. A summary of the work on curing at low temperatures is also presented. New information about rapid curing at low temperatures and the use of photopolymerization techniques are also discussed.

Polymer Particle Size and Distortion

This study has been continued to check the results which were presented in the previous report. The discrepancies of those results were no doubt due to errors of measurement and efforts were therefore made to minimize these effects.

Two denture blanks were made with methyl methacrylate monomer and Lucitone polymer retained on an 80-mesh screen and two were made with monomer and Lucitone polymer which passed through a 100-mesh screen. These four blanks were processed by the thermoduct method.

After conditioning in water at room temperature for at least two days, the dentures were marked with gauge-marks on the ridges and flanges and measured on a travelling microscope.

The dentures were then invested in plaster in the usual way for making repairs, and re-cured at 160°F. for 6 hours. No new denture base material was added. Measurements were again made and then another re-cure was done by heating the blanks to 212°F. in 1-1/2 hr.

The changes in dimensions which occurred as a result of these "repair" conditions are shown in the following table.

.... 2

Dimensional Changes on Re-curing Dentures
Made with Fine and Coarse Polymer

Dimensions of Dentures in mm.

Denture	Original		After 6 hr. at 160°F.		After 212° F.	
	Flange	Ridge	Flange	Ridge	Flange	Ridge
Coarse No.3	61.3	46.0	61.0	45.8	60.7	45.6
Coarse No.4	61.1	45.4	60.8	45.2	60.5	45.0
Fine No.3	61.0	44.9	60.7	44.7	60.4	44.5
Fine No.4	60.9	45.3	60.6	45.1	60.3	44.9

Percentage Decrease in Dimensions

Denture	After 6 hr. at 160°F.		After 212°F.	
	Flange	Ridge	Flange	Ridge
Coarse No.3	.49	.44	.98	.87
Coarse No.4	.49	.44	.98	.88
Fine No.3	.49	.45	.98	.89
Fine No.4	.49	.44	.98	.89

These results show no distinct difference in distortion between the fine polymer dentures and the coarse polymer dentures. Furthermore, each re-cure produced about the same amount of distortion and these amounts appear to be additive. Since we were interested chiefly in the effect of the fine and coarse polymers, we did not continue this study to learn if additional re-cures would cause further distortions of about the same degree.

Low-Temperature Polymerization

The study of the polymerization of methyl methacrylate denture base material at 135°F. for various time intervals and under the influence of several peroxide catalysts has been virtually completed.

The criterion of a suitable cure is the A.D.A. transverse strength test. A satisfactorily strong material must have a deflection less than 2.6 mm. at a load of 4000 grams, a deflection between 3.0 and 8.0 mm. at a load of 6000 grams and an average maximum load of at least 6000 grams. The following table lists all the experimental results obtained for cures at 135°F. using Lucitone polymer and the monomers and catalysts as indicated. In addition we have measured the strength of Lucitone when cured by the presently accepted repair method, viz. at 160°F. for 9 hours or longer.

Transverse Strengths for Cures at 135°F.

Monomer Used	No. of Specimens	Catalyst Used 1	Cure Time at 135°F	Knoop Hardness	Deflections at 4000gm.	Deflections at 6000 gm.	Av. Max. Load
Lucitone	3	-	10 hr. at 160°F.	12.0	2.09	4.30	6900
"	3	-	24 hr.	13.8	2.53	6.09	6500
"	4	-	16 hr.	13.7	2.51	-	5850[2]
Inhibitor-free	4	-	24 hr.	13.2	2.44	5.57	6700
"	4	-	16 hr.	12.3	2.36	5.88	6650
"	4	benzoyl peroxide	24 hr.	14.5	2.54	5.95	6100
"	2	"	16 hr.	15.5	2.08	4.46	7500[3]
"	2	"	16 hr.	15.5	2.37	5.50	6750[3]
"	2	"	12 hr.	13.1	2.87	8.96	6000[2]
"	4	t-butyl perbenzoate+ Accelerator 1000	16 hr.	14.2	2.35	5.06	6750
"	3	"	12 hr.	12.6	2.54	5.89	5800[2]
"	4	Uniperox 60	24 hr.	14.0	2.38	5.25	6750
"	3	"	12 hr.	10	2.65	-	5800[2]
"	2	" + fine polymer	24 hr.	14.3	2.14	4.62	7150

1 Concentration of catalysts was 0.1% based on weight of monomer.

2 Fails to pass transverse strength test.

3 Variation caused by difference in sizes of dental flasks.

Several facts are at once evident from this table.

(1) There appears to be no direct relation between Knoop hardness values and transverse strength. There are several instances where a softer material has greater strength than a harder material and vice versa. It is, of course, desirable to have a material which has adequate strength as well as maximum hardness.

(2) Cures for 24 hours at 135°F. will produce a polymer of satisfactory strength although in one case, where the combination of inhibitor-free monomer and benzoyl peroxide was used, the flexibility at 4000 grams load and the average maximum load are very close to the specifications limits. This behaviour is rather anomalous in view of the fact that samples cured for 16 hours are much stronger and also harder.

(3) Overnight or 16-hour cures at 135°F. produce strong polymers when inhibitor-free monomer and no catalyst are used and also when the same monomer is used with benzoyl peroxide or t-butyl perbenzoate and Accelerator 1000 as catalysts. The combination of greatest strength and hardness for a 16-hour cure is obtained with inhibitor-free monomer and 0.1% benzoyl peroxide. The strength of this material is comparable to that cured at 160°F. for 10 hours.

(4) Cures of less than 16 hours fail to produce strong polymers. A worth-while reduction in curing time would be to cut at least 8 hours from this time, so that it would be possible for dentists and technicians to complete a repair within a working day.

Ultra-violet Irradiation

It is proposed to study the effect of ultra-violet radiations on the polymerization of methyl methacrylate. It is hoped that, after a short preliminary heat treatment to set and shape the denture base material, polymerization can be carried to completion by radiations from a mercury vapour lamp. Four hours at 135°F., and possibly even less, is sufficient time for the preliminary cure.

We have ordered the necessary ultra-violet equipment and while we are awaiting its delivery we have started some investigations using a mercury lamp of medium intensity. There is little to report on these developments, except to note that with our present apparatus we have been able to polymerize monomeric methyl methacrylate to a rather hard polymer in about five hours.

Discussion of Patent

Accompanying this report is a synopsis of Canadian Patent No. 440,240 which is owned by Canadian Industries Limited. This patent claims the methods of polymerizing methyl methacrylate and related compounds for use in making direct inlays, crowns and similar reconstructions and as dental cements. Special light-activated catalysts such as benzoin, diacetyl and others are used.

The claims are extensive and were obviously formulated to cover this specific field as completely as possible. It is noted that light of wave-lengths from 1800 or 7000 Å are described for use but this appears so general that some doubt as to its validity immediately arises. This suggests that it might be desirable to test the claims of the patent and it would be feasible for us to do so.

Other Catalysts

A literature search has revealed that in Germany during the war a special catalyst, trihexylamine, was used for the rapid polymerization of methyl methacrylate at low temperatures. With the use of this catalyst, it was possible to make direct acrylic inlays in a few minutes.

We have located a source of trihexylamine and are presently waiting for a research sample which has been promised to us.

The information in the above-mentioned patent and that about trihexylamine is doubly interesting. Not only does it suggest possible solutions to the problem of repairs, but it also should have considerable bearing on the problem concerned with cements for methacrylate inlays. A satisfactory method of making direct acrylic inlays would to a great extent obviate the necessity for making indirect acrylic inlays.

Future Work

1. Make actual repairs on experimental dentures to check the results presented in this report.

2. Carry out studies of the polymerization of methyl methacrylate under the influence of ultra-violet light.

3. Investigate the use of trihexylamine as a low-temperature catalyst.

4. Possibly check the claims of Canadian Patent 440,240.

January 28, 1948.

Description and Claims of Canadian Patent No. 440,240

Granted March 18, 1947 to Canadian Industries Limited

(assignee, Frederic Charles Hahn)

for

"Light - Activated Dental Material"

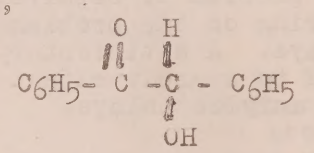
Description

(a) Uses - The material of this invention is for use in crowns inlays and similar tooth reconstructions and in dental cements and the like.

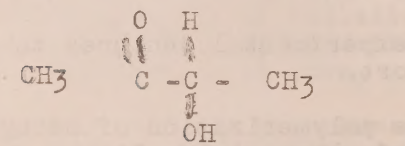
(b) Materials -

(1) Any photopolymerizable monomer which will polymerize to a material adaptable for dental reconstruction. Specifically, a monomer of acrylic or methacrylic acid or an ester or anhydride of these acids.

(2) A light-activated catalyst used in concentrations of 0.01% to 2% but preferably of 0.5 to 1.0%. The catalyst may belong to the class of α-carbonyl alcohols, whose general formula is $R - C(=O) - C(H)(OH) - R'$.
(R and R' may be the same or different and are hydrogen atoms or monovalent hydrocarbon radicals). A sub-class are the aceloins where R and R' are aliphatic or aromatic hydrocarbon radicals. For example,



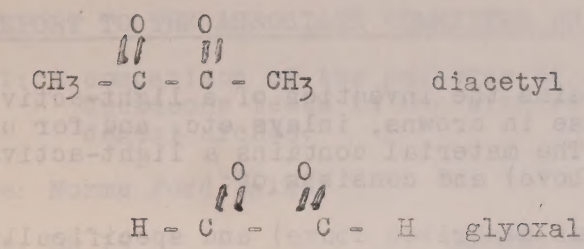
benzoin and



acetoin

Another class of catalysts is the group of polyketaldonyl compounds of the general formula $R(CO)_n R'$ where n + 2 or 3 and is preferably 2 and where R and R' are hydrogen or monovalent aliphatic or aromatic hydrocarbon radicals. For example,

(.... 2)



diacetyl

glyoxal

(3) A peroxide catalyst, such as benzoyl peroxide, may be used in addition to the photopolymerization catalyst.

(4) A polymer is preferable but not essential. The polymer is preferably a polymer of one of the monomers mentioned above. It need not have a photopolymerizable monomer and it may be an interpolymer and the polymer should be soluble in the monomer. The ratio of polymer to monomer may be 80/20 to 50/50 but is preferably 60/40.

(c) Polymerization - The monomer can be polymerized in 15 minutes or less by irradiation with light of wavelength 1800 to 7000 Å.

(d) General- Dyes, pigments and plasticizers may be added in amounts which will not destroy the translucency of the monomer-polymer mixture and so that hardening will occur in 15 minutes or less and at the most in 30 minutes.

The dental restoration may be formed by successive deposition of 2 or more layers of material, differing slightly in colour, to simulate colour gradations of natural teeth.

The inclusion of .001% to 1.0% of methacrylic anhydride will give good adhesive properties. The use of 0.9 to 3.0% of methallyl methacrylate gives "properties desirable in materials for use in operative and prosthetic dentistry".

In deep cavities a lining of zinc phosphate cement may be used to protect a vital pulp.

"While the present invention is intended principally for operative dentistry, it may also be employed for the formation and repair of dental prosthetics. Complete teeth, bridges and restorations, as well as repairs to dentures, may be made in the mouth".

Claims

This patent claims the invention of a light-activated dental material for use in crowns, inlays etc. and for use as a dental cement. The material contains a light-activated catalyst (described above) and consists of:

1. A monomer (as described above) and specifically, methyl methacrylate.

2. A mixture of 50-80% polymer and 50-20% monomer, specifically methyl methacrylate monomer and polymer and methallyl methacrylate monomer.

The patent also claims the invention of the steps involved in operative dentistry of applying, to a natural tooth in situ, the material either as a cement or for a restoration and then polymerizing its monomeric component by the action of light.

APPENDIX "C"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of dental arches.

Grantee: Norma Ford Walker

Project: DR 15 Amount of Grant: $3,000.

SUMMARY OF WORK

Up to the present 86 children have been studied, including 15 pairs of twins. This number will be increased to at least 100 children and the series will then permit of comparisons being made between uniovular twins, binovular twins, sib-pairs and unrelated like-sexed pairs. For all these children we have records of the time of eruption of each deciduous tooth.

For each child dental impressions and casts have been made and from the latter measurements of the dental arches have been carefully calculated. Comparisons are now being made of these measurements with the patterns of eruption of the deciduous teeth, and the comparisons will be continued as the series of casts (made at 3 month intervals) are completed. From a still larger series of records which we have on file mean times of eruption and standard deviations for each deciduous tooth have been calculated and the results compared with other published data.

A most important factor in securing the co-operation of the families has been the excellent arrangement for transportation which we have been able to offer.

30 December, 1947.

"C-2"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of the dental arches.

Grantee: Norma Ford Walker

Project No.: DR 15 Amount of Grant: $3,000.

SUMMARY OF WORK

Since the December report was submitted two general charts for study purposes have been prepared. The first of these gives the mean eruption times and standard deviations for the deciduous teeth, as calculated from the Toronto data. The pattern of eruption for each child studied is entered on a separate copy of this chart and it can then be seen at a glance whether or not a child is deviating from the average range of eruption times.

A second chart gives the mean widths of the dental arches at varying ages as compiled by Lewis and Lehman '29. On one of these charts are entered the measurements for each child. Standard deviations were omitted to simplify this particular stencil, but they can be read off with a superimposed transparent chart. The second series of impressions are now being taken and some interesting results are emerging, particularly in the cases of children between 5 and 6 years of age, for whom over a period of 3 to 4 months there may be losses for all maxillary and mandibular measurements, or in cases of malocclusion losses on one jaw and gains on the other.

It is premature to attempt to correlate the patterns of eruption with the types of occlusion, but the assembled data should finally give an answer and also throw more light on the fundamental problem of the significance of the "falling-off periods". We recommend that two more years of study should be given to the problem.

Date: February, 1948.

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It is premature to attempt to correlate the patterns of eruption with the types of occlusion, but the assembled data should finally give an answer and also throw more light on the fundamental problem of the significance of the 'failing-off period'. We recommend that two more years of study should be given to the problem.

Date: February, 1944.

APPENDIX "C"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

February, 1948.

Subject: A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of the dental arches.

Grantee: Norma Ford Walker

Project No.: DR 15 Amount of Grant: $3,000.

SUMMARY OF WORK

In reviewing the work of the year, it should first be pointed out that there was a long delay in getting the dental equipment needed for this project, owing to postwar conditions. As a result, the second series of impressions of the dental arches is only now being taken and it has been impossible for the research assistant, Miss Margaret Philpotts-Brown, to assemble and present the data as an M.A. thesis (as the Department of Zoology had originally planned). However, since the results promise to be worthy of a higher degree, it has been recommended that Miss Philpotts-Brown enrol as a candidate for the Ph.D. degree and spend two more years of study upon the problem.

A second point worthy of emphasis is the fact that we seem to have demonstrated in this project how human research can be successfully carried out when a family unit must come regularly to a clinic. We have had almost 100% co-operation from all the families who were invited to be part of this study. This is in marked contrast to the poor response and lack of sustained interest which is too often the disappointing experience of investigators. The fine co-operation of our families has resulted from the set-up of the project, which psychologically is good, including the ease of transportation, the quiet, professional atmosphere of Dr. Aho's private office, and the undivided attention given to one family unit at a time by both the dentist and biologist. All these factors have been reflected in the satisfactory comments from the parents.

As to the results of the study, one of the first tasks was to work over the records in our files of the eruption times of the deciduous teeth. Independently the Fels Research Institute (at Yellow Springs, Ohio) had undertaken the same problem, since published data had previously been unsatisfactory. In both studies the methods of collecting data and the economic status of the families are much the same. The two sets of results are also in

close agreement as shown by the table on page 2A. It will be noted that the number of children in the Toronto study, for whom there are complete records, is almost twice that of the Fels study, namely 122 to 64.

For special purposes of the Toronto study the eruption time of each tooth was calculated separately and not as homologous pairs (See attached graph). For the preliminary survey the calculations used were based on sexes combined, but in the final study the sexes will be separated.

A general chart was then set up giving the eruption times of the deciduous teeth, so that the pattern of eruption for each child studied could be entered on a separate copy of this chart. From the chart one can see at a glance whether or not a child is deviating from the average range of eruption times.

A second chart gives the mean widths of the dental arches at varying ages as compiled by Lewis and Lehman '29 (Dental Cosmos, 71: 480). On copies of this chart are entered the measurements for each child studied. Standard deviations were omitted to simplify this particular stencil, but can be read off with a superimposed transparent chart.

One of the most interesting results which emerges from the measurements of the casts taken at intervals of 3 - 4 months for children of 5 - 6 years is the surprising record of the periodic losses in width followed by "springing-up periods". Such a pattern of growth is not generally appreciated, but Broadbent '37 (Angle Orthodontist, 7: 209) reminds us that the decreases which take place in the width of the dental arch "illustrate very graphically the developmental trend and impress upon us the limitations encountered when one attempts to record developmental changes by just a measurement of dimensions, with the expectation that there should always be an increase in the size with the passage of time".

To illustrate the method of study several charts are attached. These include:

1. Records of a pair of binovular twins, Gary and Guy J.

The diagnosis of the twinning type of this pair of twins is based on (i) a study of their placenta, made at the time of birth, and preserved in the Department of Zoology, and (ii) on a recent analysis of their dermal patterns.

From the charts it is seen that the patterns of eruption of their deciduous teeth follow quite closely the means.

Age of Eruption in Days of Deciduous teeth for Homologous Pairs, Sexes Combined.

(A comparison of the Toronto and Fels data)

	Toronto Data		Fels Data Yellow Springs, Ohio	
Numbers Records for all 20 dec. teeth	122 children (55 ♂♂, 67 ♀♀)		64 children (31 ♂♂, 33 ♀♀)	
Incomplete records.	182 children (92 ♂♂, 90 ♀♀)		175 children	
Total	304 children		239 children	
	Age in days.		Age in days.	
	Mean	S.D.	Mean	S.D.
Lower Cent. Incisor	234.3	55.9	228	55.5
Upper Cent. Incisor	292.9	56.7	282	52.5
Upper Lat. Incisor	317.7	60.7	333	76.5
Lower Lat. Incisor	378.7	86.5	402	96.0
Upper First Molar	482.3	80.1	474	69.0
Lower First Molar	499.3	85.2	477	60.0
Upper Canines	569.1	110.2	585	88.5
Lower Canines	580.2	105.3	594	94.5
Lower Sec. Molar	799.8	109.5	795	120.0
Upper Sec. Molar	827.3	144.2	840	130.5

Impressions of their teeth were taken at 4 months interval, between the 5th and 6th year. The measurements of the widths of their dental arches are interesting in that one twin(Gary), who had the wider jaws, is in the "Falling-off stage", except for the measurement between his mandibular canines. The increase of the latter measurement is associated with the eruption of his permanent left central incisor. The other twin (Guy) who has the narrower jaws, is in the "springing-up stage" for his mandibular measurements. During this period Guy lost by extraction his left upper first molar, and since the second impression was taken, his remaining three left molars have also been extracted, owing to decay. Guy is reported to have "very soft teeth", Gary "very hard teeth". Such a difference is not unexpected in binovular or two-egg twins.

2. Records of a pair of uniovular twins, Donna and Diane, R.

Diagnosis of the twinning type was made as in Case 1.

Impressions of the teeth were taken at 4 and 1/2 months interval, between the 5th and 6th year.

Measurements made from the first cast showed that Donna had wider jaws than her twin, Diane. A "springing-up stage" is recorded for both twins in the growth of their mandibles between the first and second molars,while no growth has occurred in either twin for the corresponding maxillary measurements. The smaller twin (Diane) shows growth in the width between the canines for both maxillary and mandibular measurements.

3. Records of a child with malocclusion, Ann P.

In this case the pattern of eruption shows irregularity. There are earlier eruptions on the left side for each of the following homologous pairs, lower first molars, lower canines and upper second molars. Marked malocclusion is seen for each set of measurements.

4. Records of a child with normal occlusion, Ann, S.

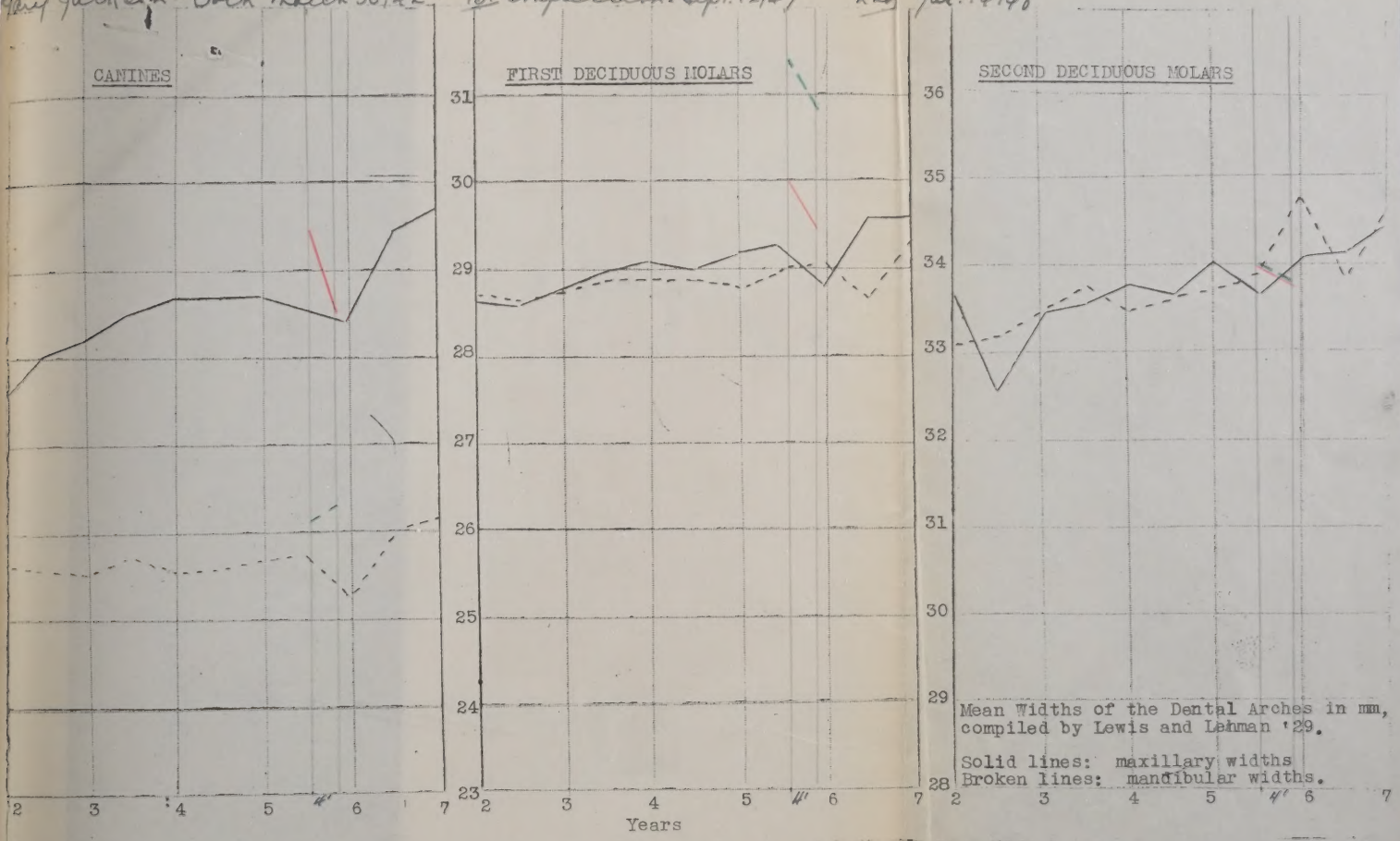
In this case the pattern of eruption consistently follows along one side of the mean, within the standard deviation. Only the first set of measurements has been calculated for the widths of the dental arches and these also are close to the means and within the standard deviations,

except for the narrower distance between the mandibular canines.

It is premature to attempt to correlate the patterns of eruption of the deciduous teeth with the types of occlusion, until we have followed through in detail the fluctuations in growth, but the assembled data should finally give an answer and also throw more light on the fundamental problem of the significance of the "falling-off" periods.

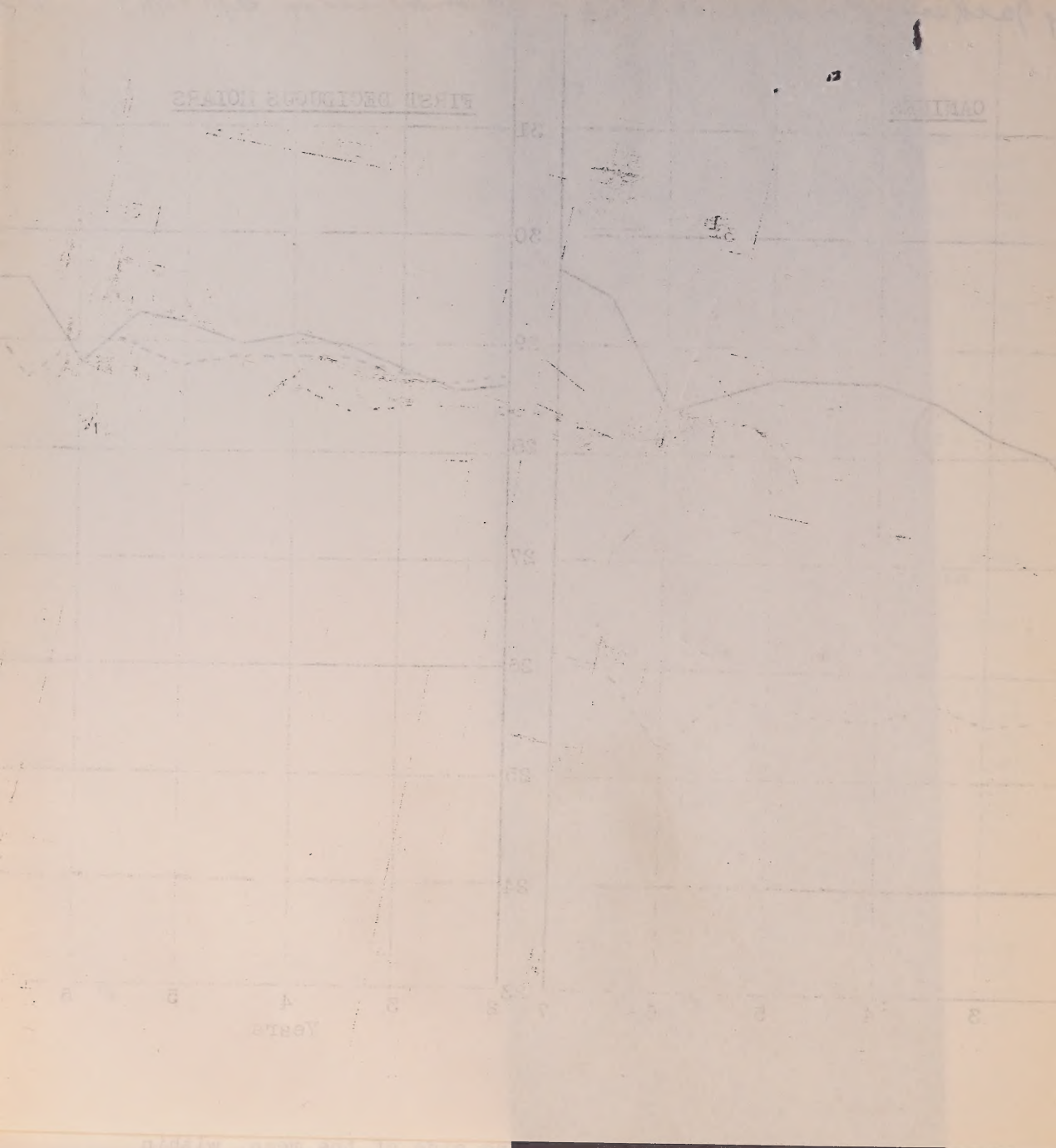
If finally it is possible to establish a correlation between the eruption pattern of the deciduous teeth and the type of occlusion, it might then conceivably become part of general dental practice to encourage parents to keep complete and accurate records of the eruption dates of all the deciduous teeth and for the pedodontist to take routinely a series of impressions at regular intervals and to have casts of these available for reference. An important argument in favour of the methods employed in this project is that, owing to their comparative simplicity, such methods could be adapted to general dental practice, whereas measurements requiring elaborate and expensive apparatus would not be feasible for the general practitioner.

Gary Jackson - Born March 30/42 - 1st Impression - Sept. 12/47 2nd Jan. 14/48

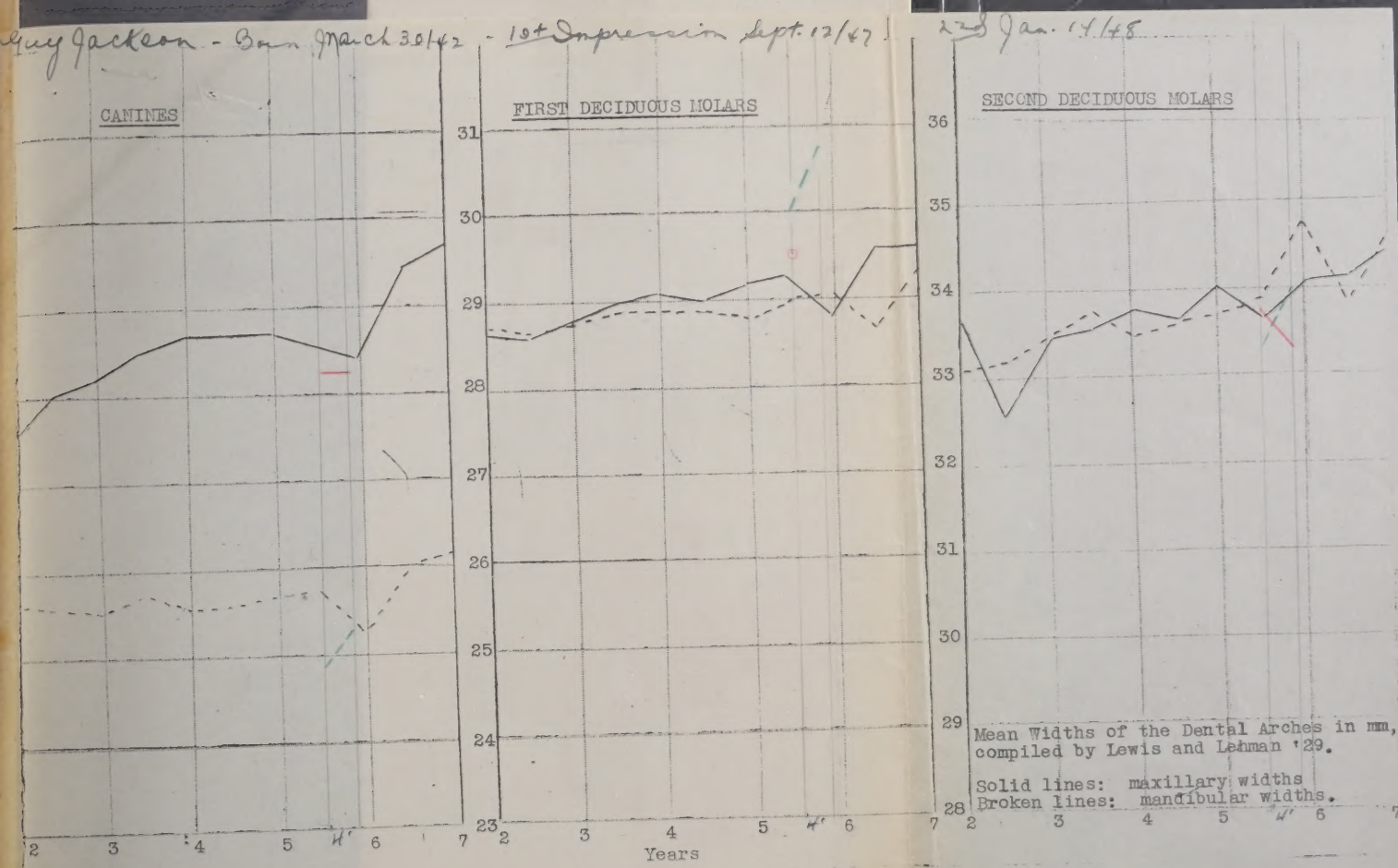


Mean Widths of the Dental Arches in mm, compiled by Lewis and Lehman '29.

Solid lines: maxillary widths
Broken lines: mandibular widths.



Guy Jackson - Born March 30/42 - 1st Impression Sept. 12/47 - 2nd Jan. 14/48



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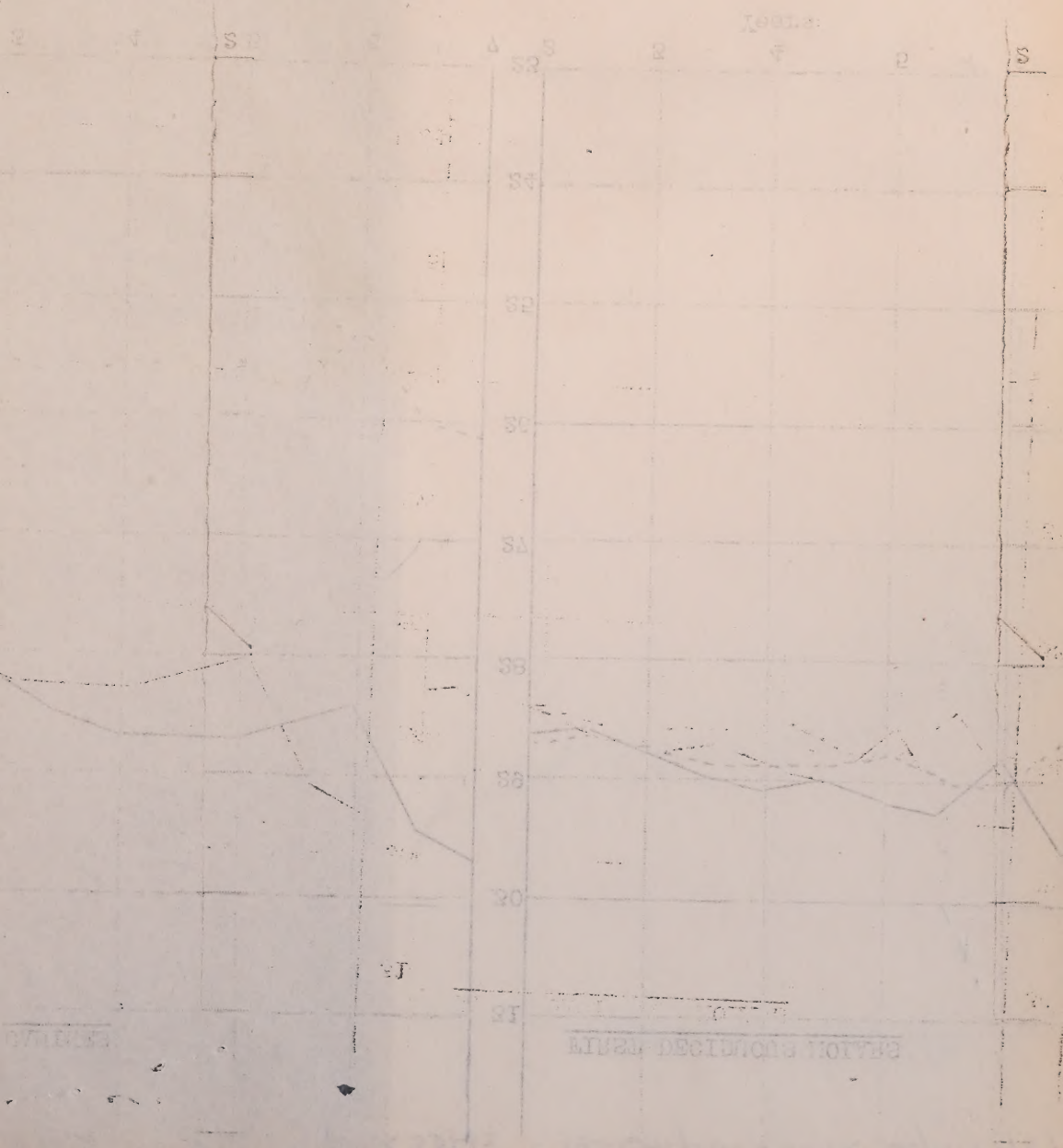
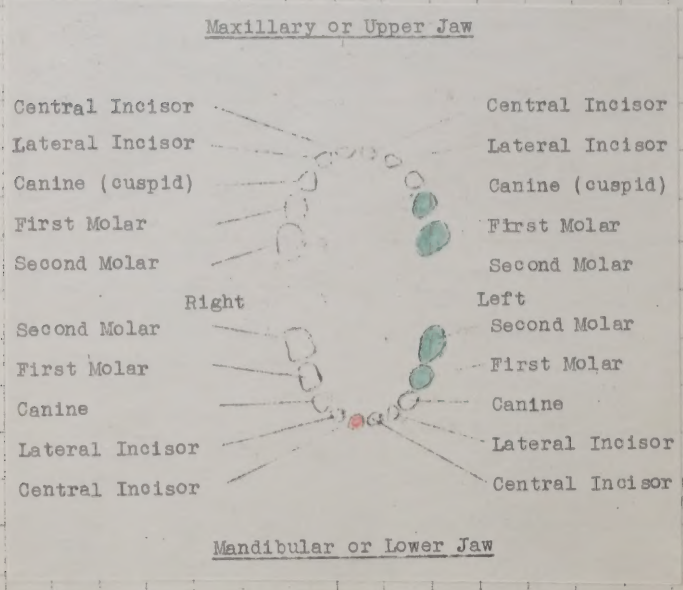


Gary Jackson

Guy Jackson

Graph Showing Mean Ages in Days (and Standard Deviations) for Eruptions of Deciduous Teeth. (Sexes Combined)



Days

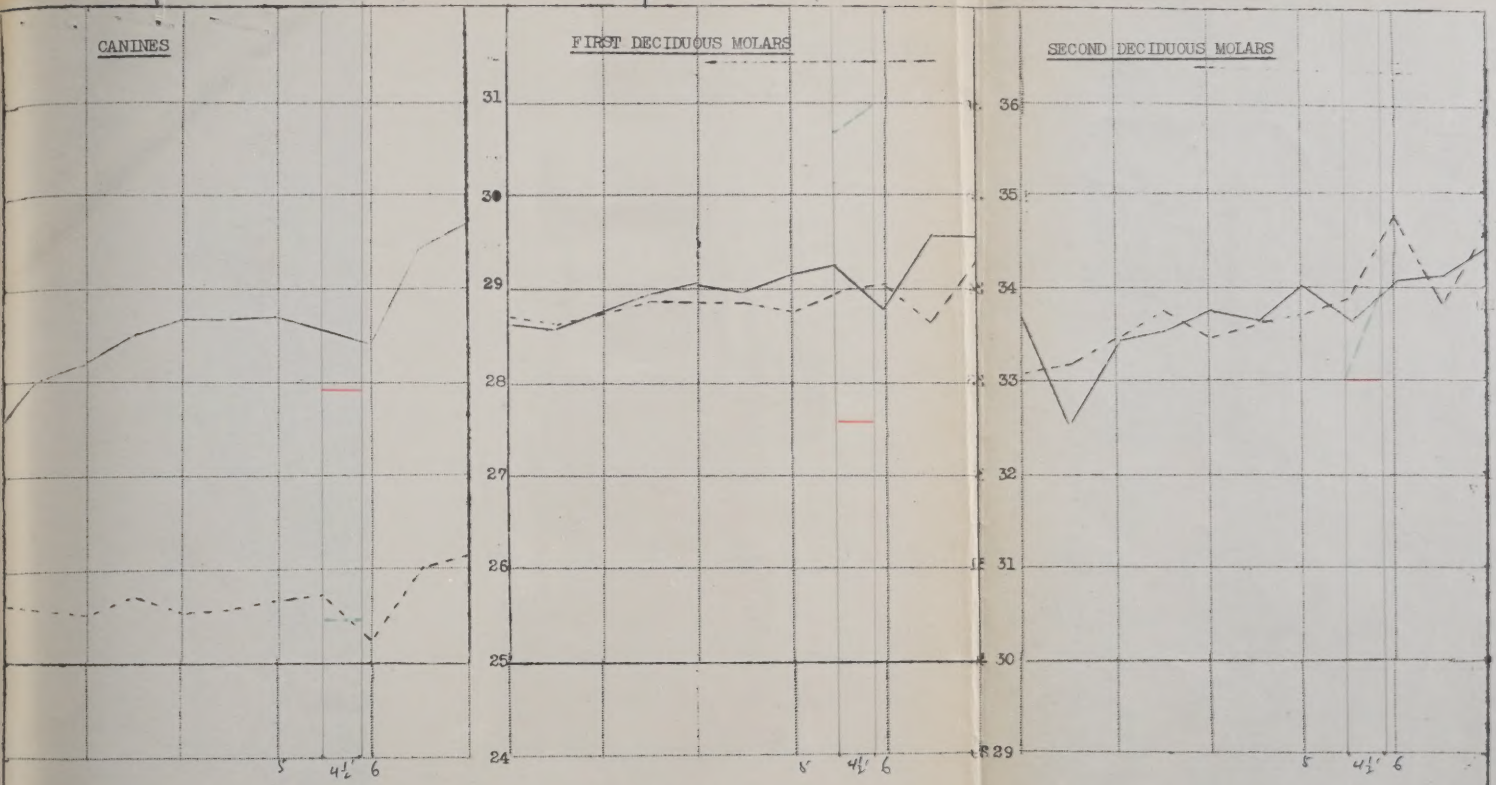
1060 1020 980 940 900 860 820 780 740 700 660 620 580 540 500 460 420 380 340 300 260 220 180 140 100

LLCI ULCI ULLI LLLI ULFM LLFM ULC LLC LLSM ULSM

LRCI URCI URLI LRLI URFM LRFM URC LRC LRSM URSM

Graph Showing Mean Ages in Days (and Standard Deviations) for Eruptions of Deciduous Teeth. (Sexes Combined)

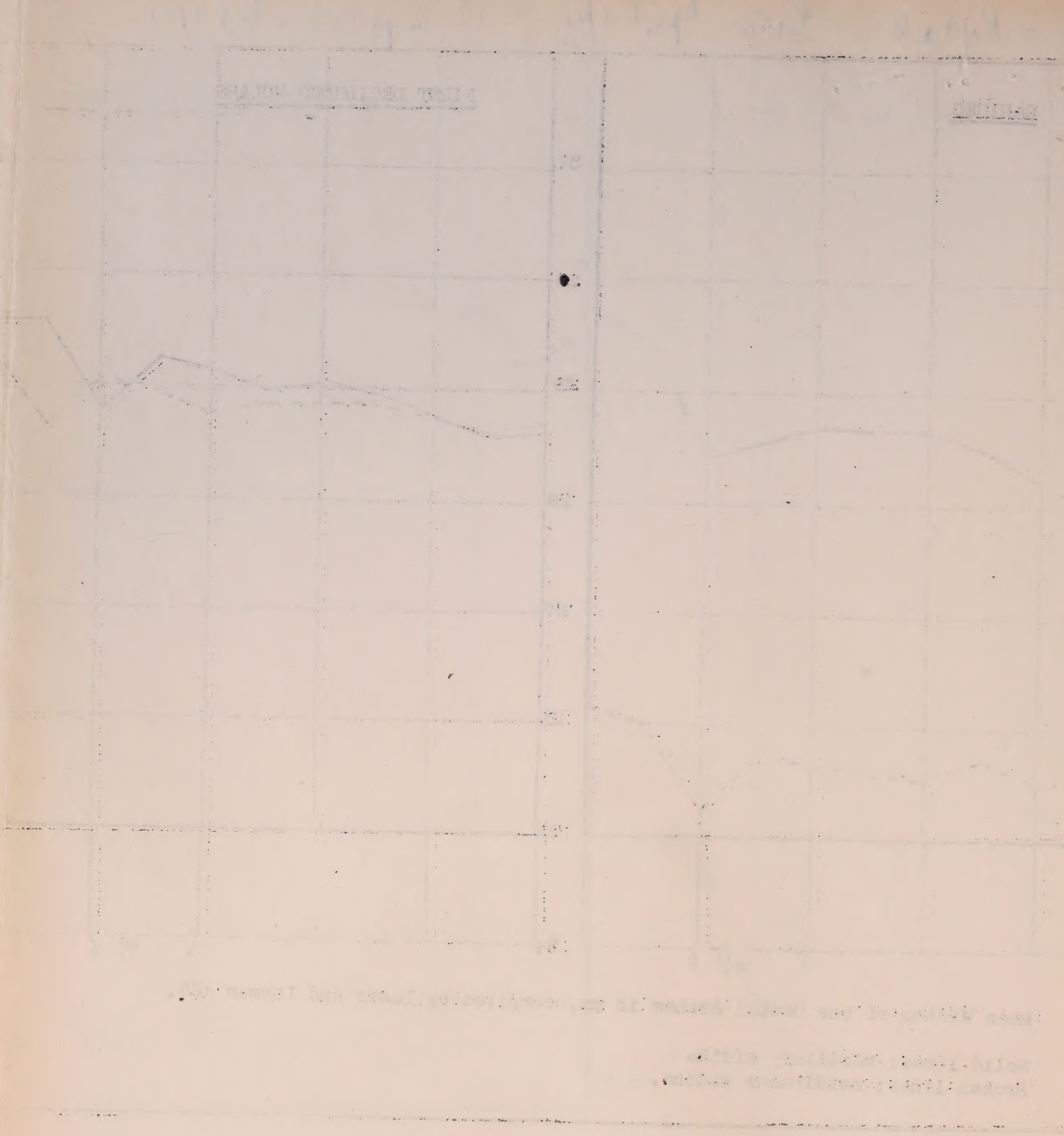
Donna Rydell. Born April 6/42 1st Impression Oct 1/47 2nd Feb. 10/48



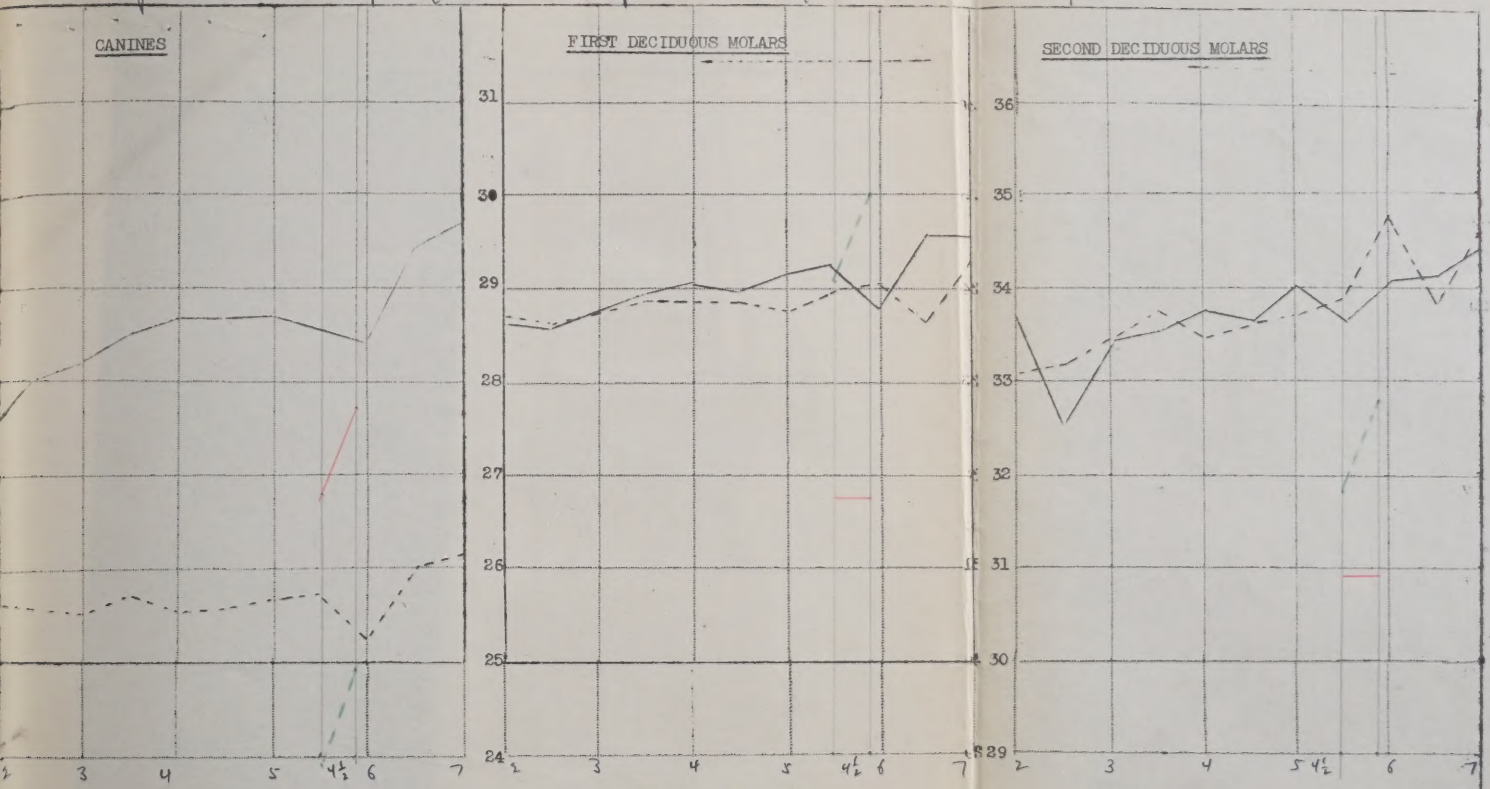
Mean Widths of the Dental Arches in mm, compiled by Lewis and Lehman '29.

Solid lines: maxillary widths. ——
Broken lines: mandibular widths. — —

← Years →



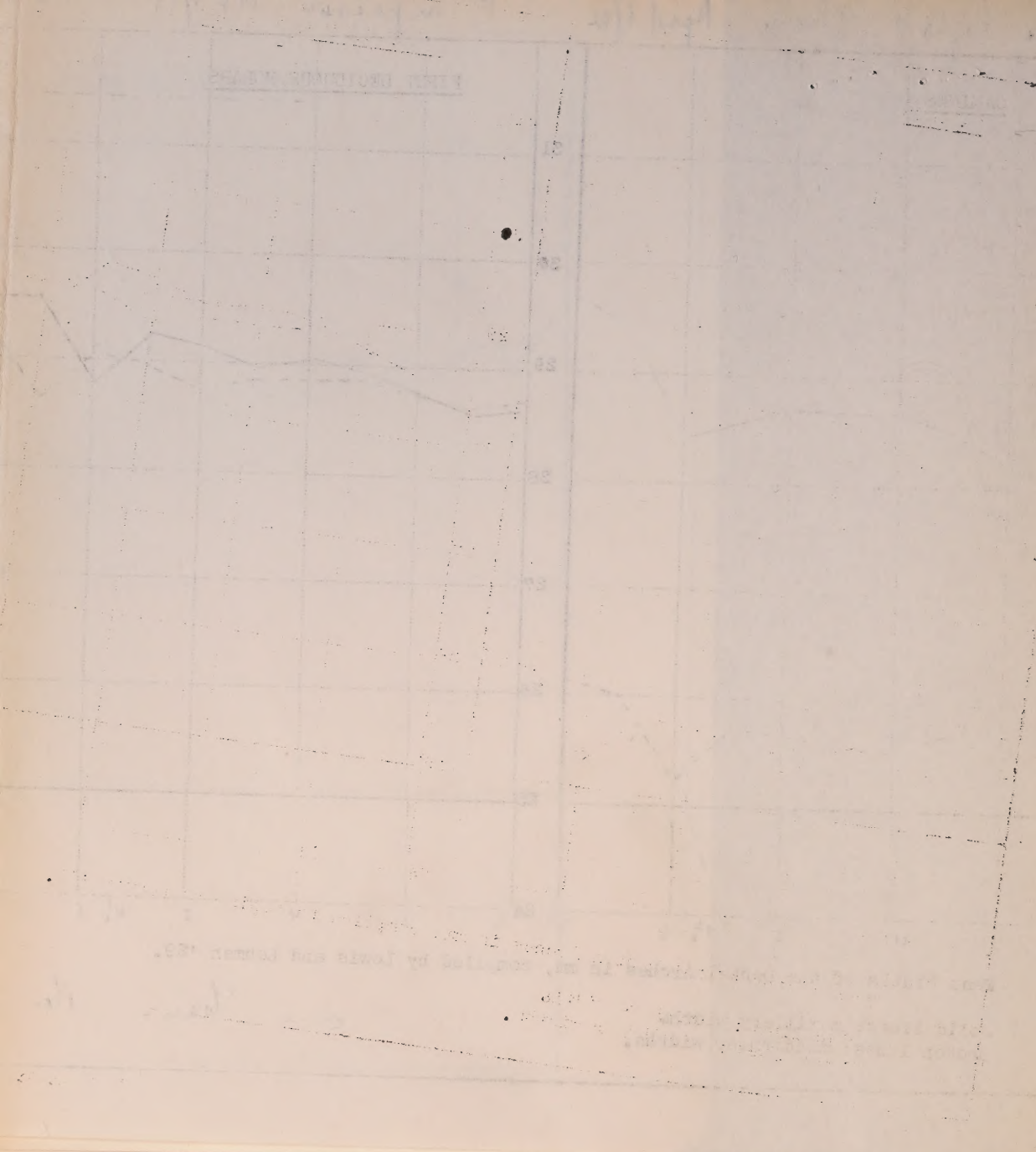
Diana Rydell. Born. April 6/42 1st Impression Oct. 1/47. 2nd Feb. 10/48

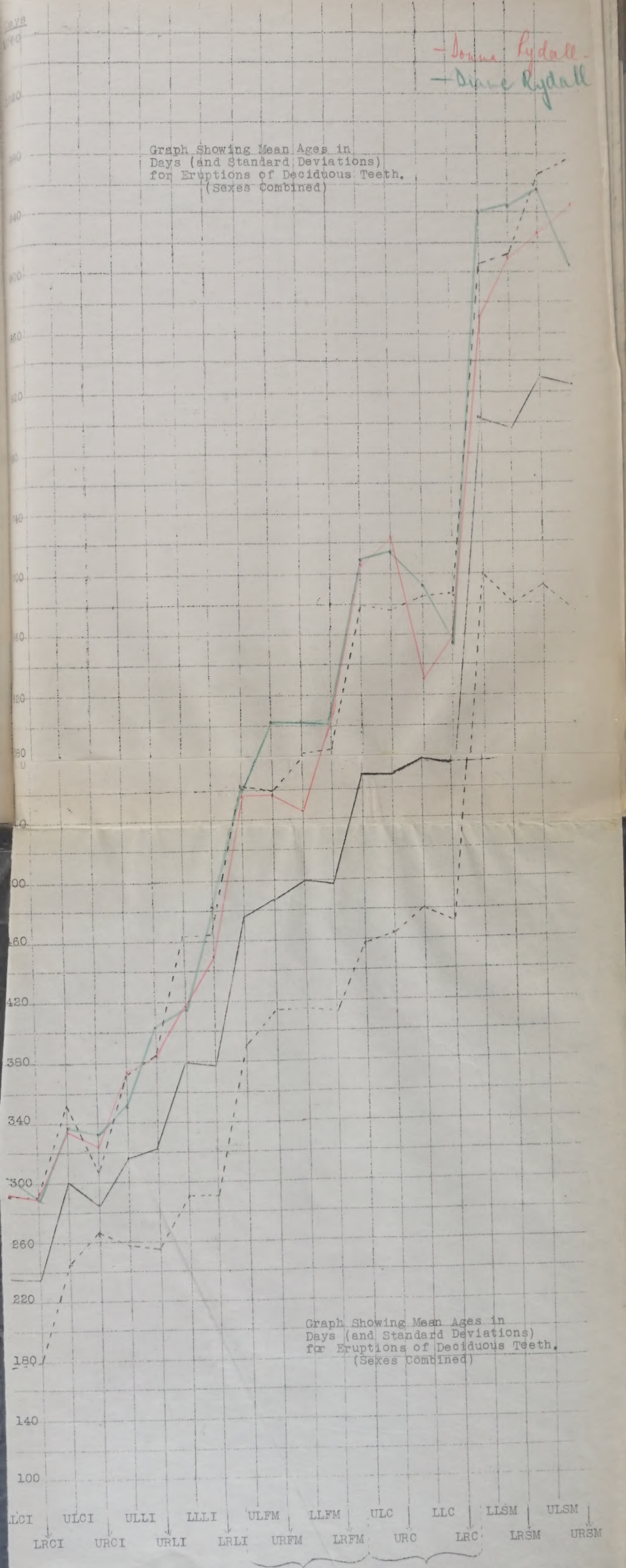


Mean Widths of the Dental Arches in mm, compiled by Lewis and Lehman '29.

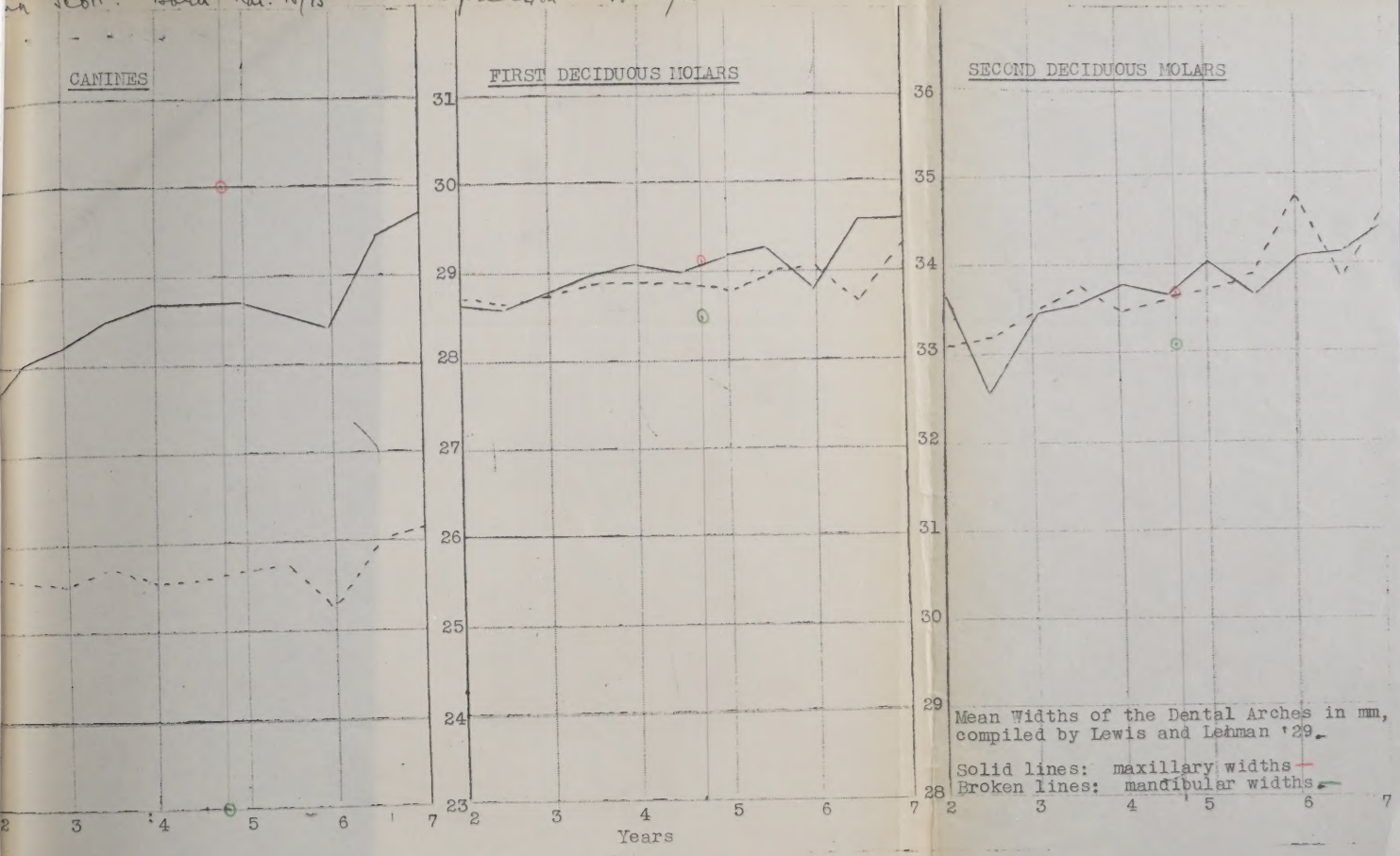
Solid lines: maxillary widths
Broken lines: mandibular widths.

← Mean - 1Ibs. →



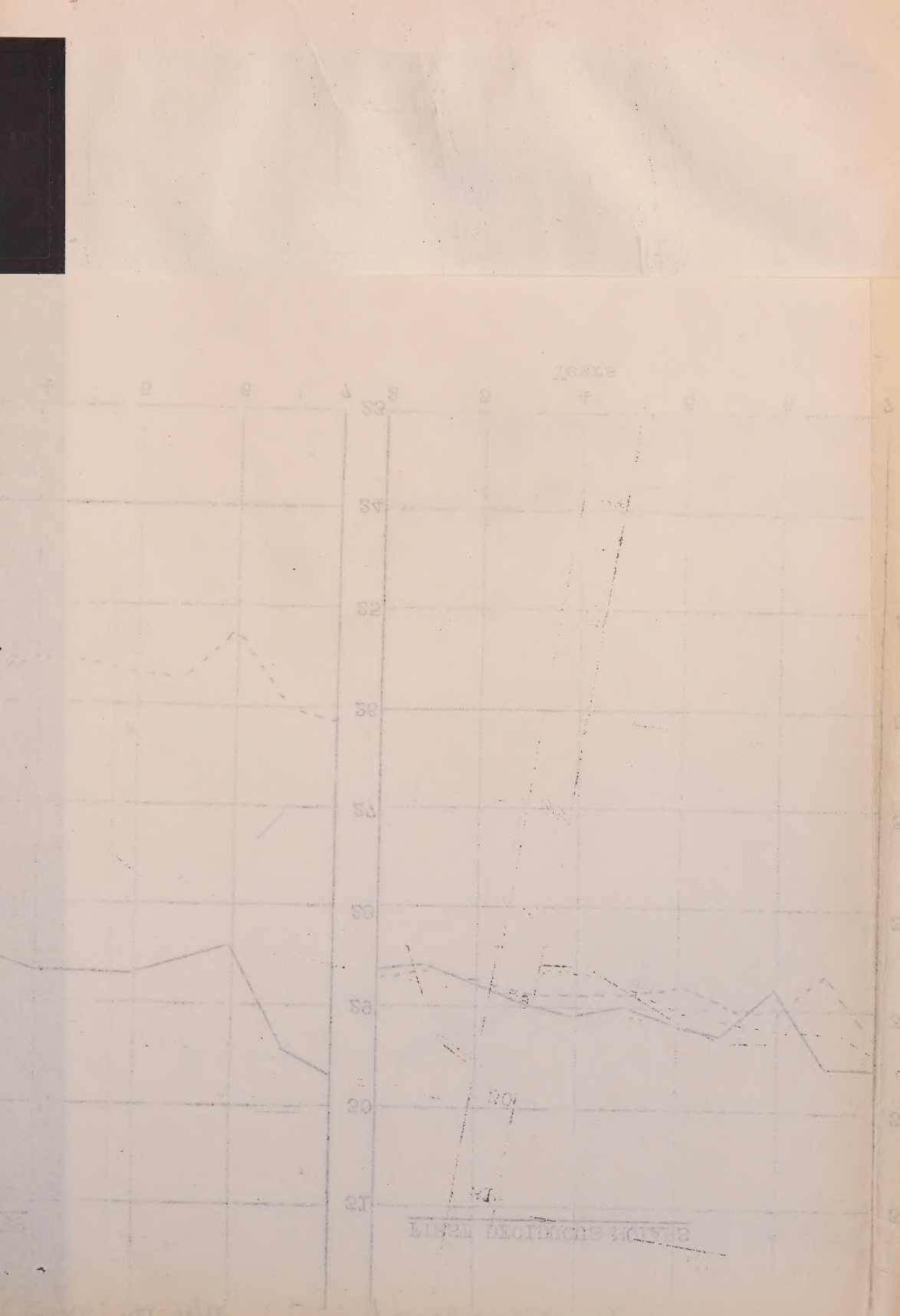

Donna Rydall
Dianne Rydall
Graph Showing Mean Ages in
Days (and Standard Deviations)
for Eruptions of Deciduous Teeth.
(Sexes Combined)
420
380
340
300
260
220
180
140
100
LLCI
ULCI
ULLI
LLLI
ULFM
LLFM
ULC
LLC
LLSM
ULSM
LRCI
URCI
URLI
LRLI
URFM
LRFM
URC
LRC
LRSM
URSM

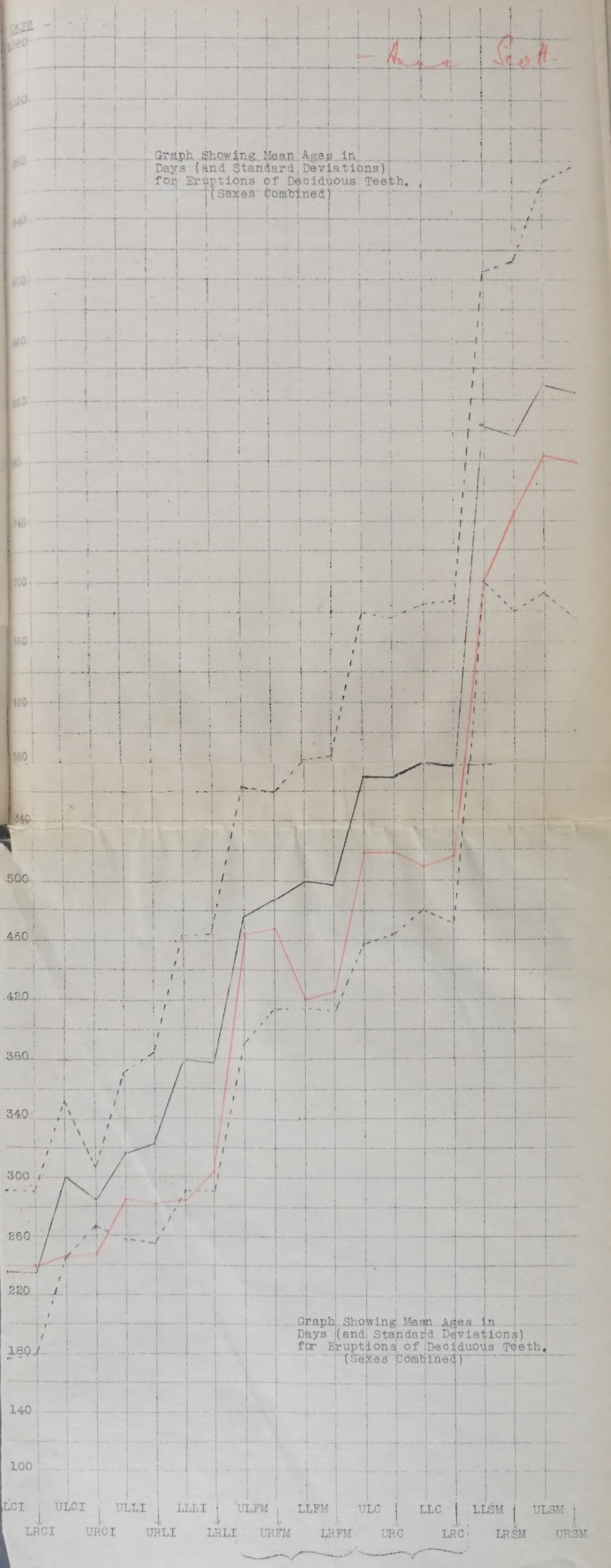
Scott. Born Mar. 16/13 1st Impression Nov. 19/17



Mean Widths of the Dental Arches in mm, compiled by Lewis and Lehman '29.

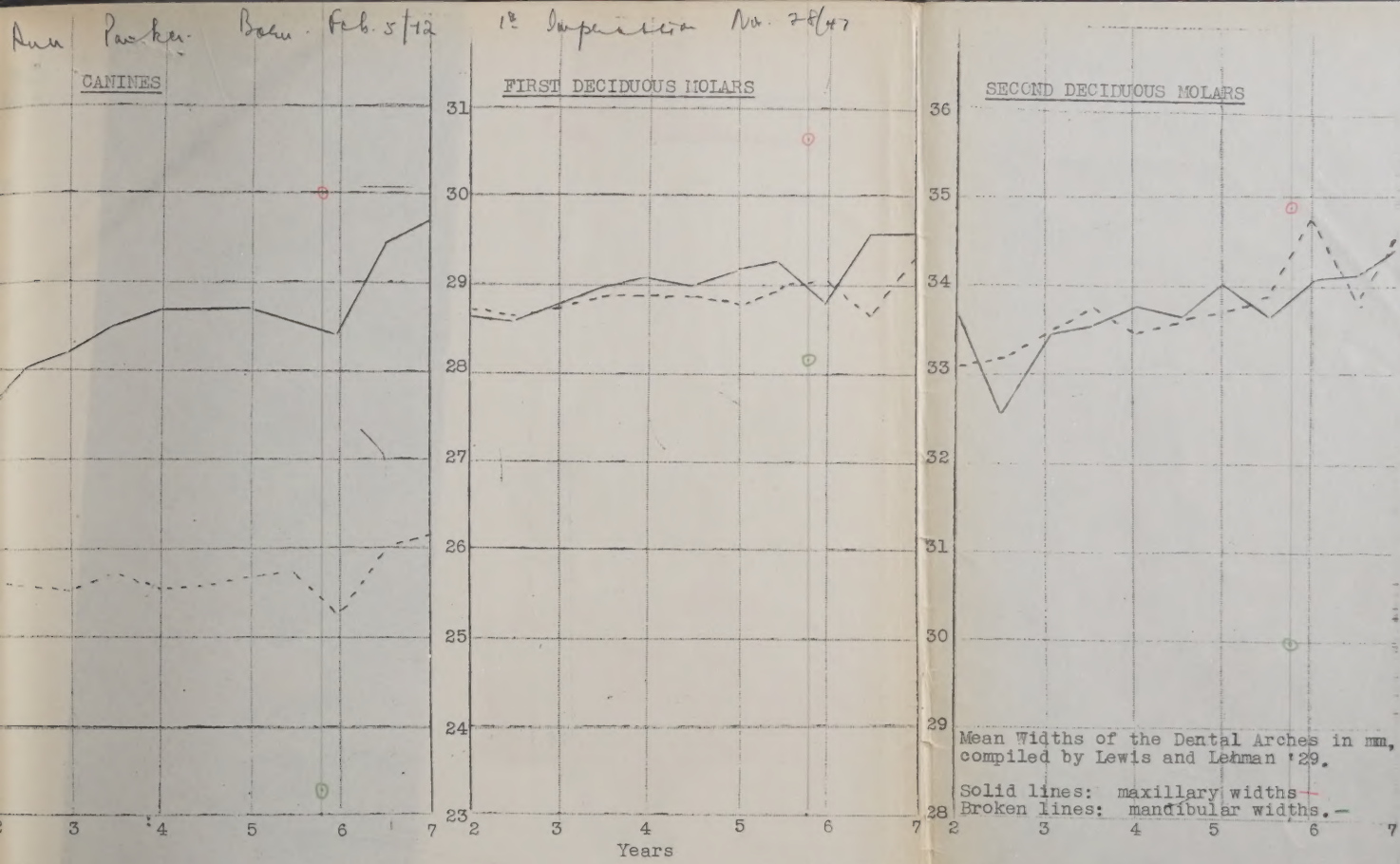
Solid lines: maxillary widths
Broken lines: mandibular widths





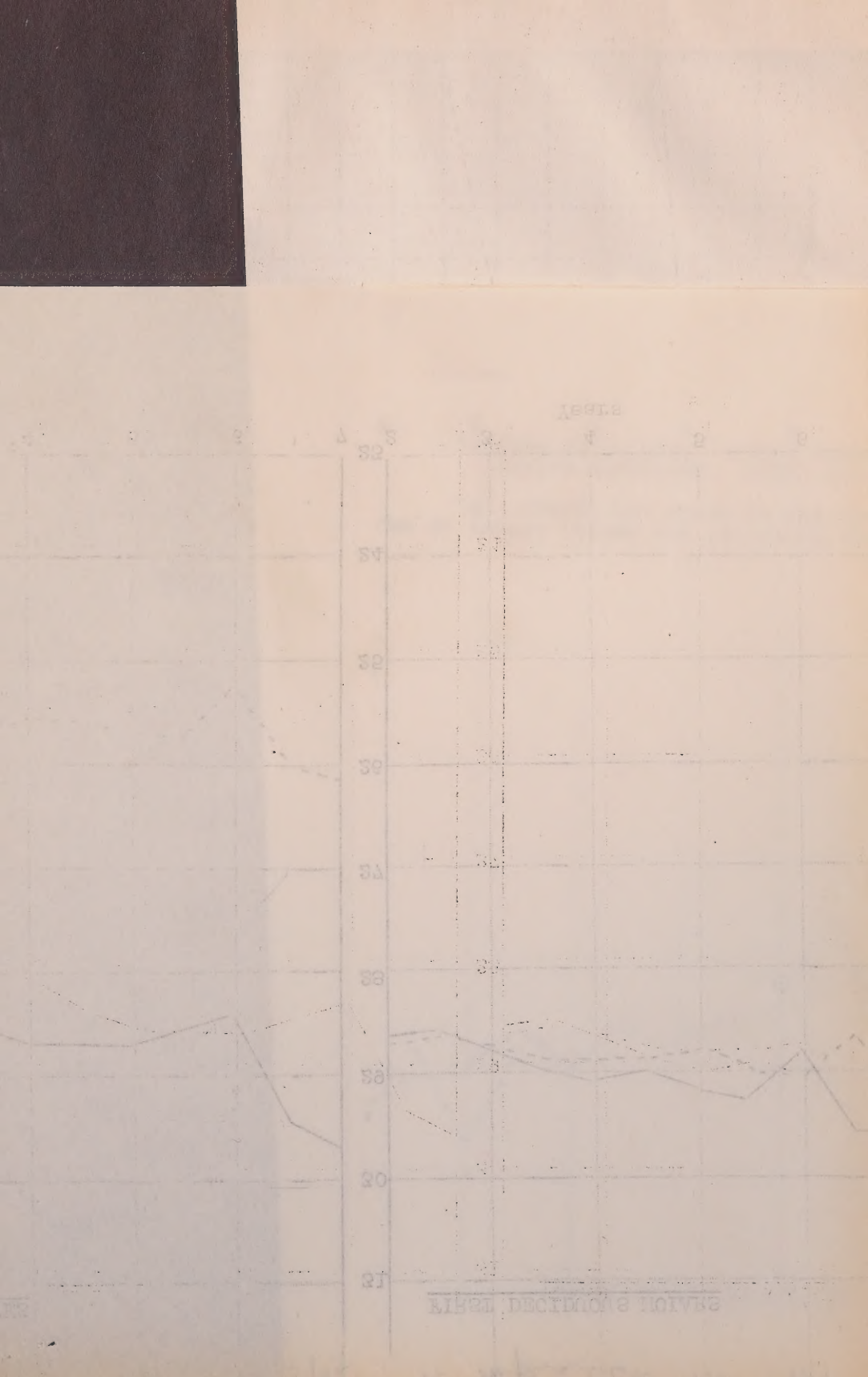
Graph Showing Mean Ages in
Days (and Standard Deviations)
for Eruptions of Deciduous Teeth.
(Sexes Combined)

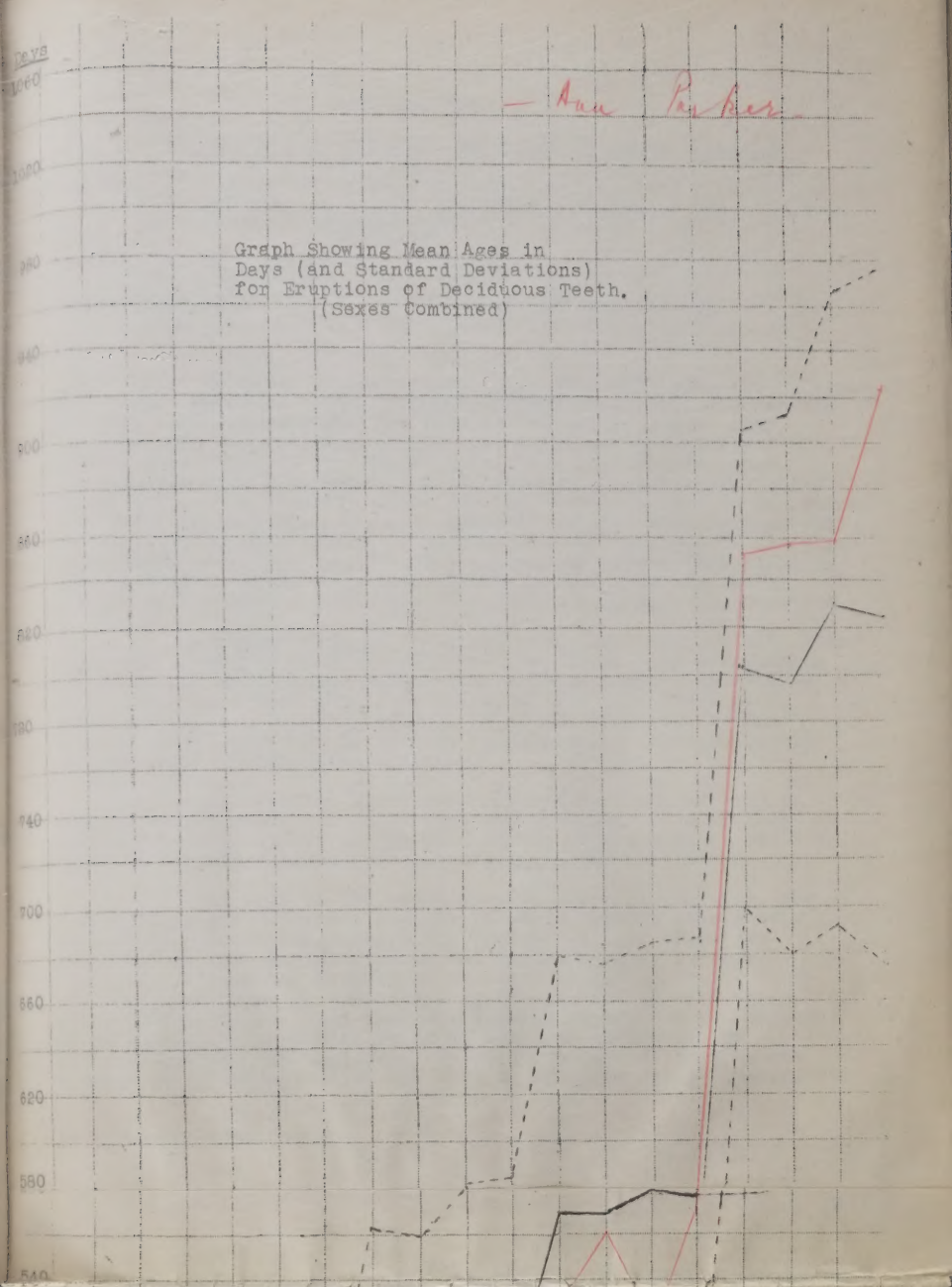
Ann Parker Born Feb. 5/12 1st Inspection No. 78/47

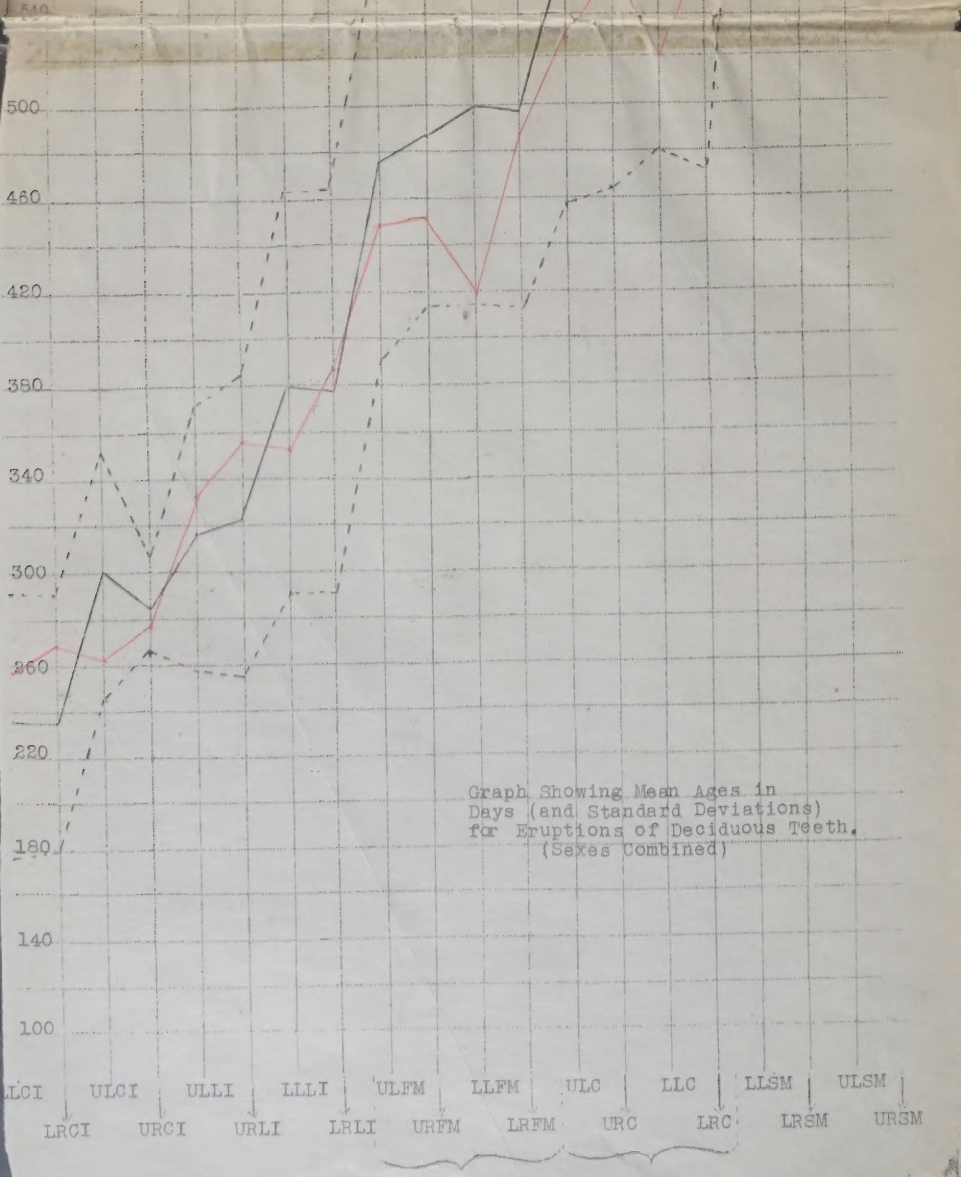


Mean Widths of the Dental Arches in mm, compiled by Lewis and Lehman '29.

Solid lines: maxillary widths —
Broken lines: mandibular widths. - - -







Graph Showing Mean Ages in
Days (and Standard Deviations)
for Eruptions of Deciduous Teeth.
(Sexes Combined)

APPENDIX "D"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: A study of micro organisms found in deep periodontal pockets and caries lesion as revealed by the electron microscope.

Grantee: H. K. Box

Project No.: DR 3 Amount of Grant: $ 500.

To date, 96 photographs have been made with the electron microscope. Material taken from deep periodontal pockets shows the presence of fusiform organisms both curved and straight, with numerous long and very fine filaments, which are apparently peritrichate. Beust, in 1909 reported that the conidia of an organism named by him, Leptothrix falciformis, had a peritrichial flagellation. He regarded these falciform spore bodies as identical with fusiform bacilli. It is of interest to note that Smith (1932) and Hine (1935) were unable to demonstrate the presence of flagella on fusiform bacilli. In 1943, Boe apparently showed that flagella were present on these organisms. In one of our examples, early rosette or cockle-bur formation of fusiform organisms was observed.

Crescent-shaped organisms have been observed with fine filaments extending from the concave side. These seem to resemble the Spirillum sputigenum. Spirochetes varying greatly in size and undulations have been noted. No flagella have been observed on these organisms. Constrictions at intervals along the bodies of long spirochetes are to be seen which possibly have to do with reproduction by transverse division.

In material taken from carious dentine, myriads of coccoid bodies varying in size were demonstrated. The average diameter is approximately 1/50 of a micron. These bodies were not found in scrapings taken from sound normal-looking dentine.

As many of the mouth organisms are pleomorphic, i.e. they undergo morphological changes in their various phases of a life cycle, and as they apparently include certain organisms concerned in periodontal disease and dental caries, further light may be shed on the subject in later studies. Projects are now being conducted in artificial caries-production with acid-forming bacteria obtained from whole grain flour, and the culture of certain mouth organisms which do not grow when ordinary cultural methods are employed. Through the use of the electron microscope in these studies the various findings may be integrated.

14 February, 1948.

APPENDIX "D"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: A study of micro organisms found in deep periodontal pockets and caries lesion as revealed by the electron microscope.

Grantee: H. K. Box

Project No.: DR 3 Amount of Grant: $ 900.

APPENDIX "E"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Research on denture base materials and denture preparations.

Grantee: Dr. A.E.R. Westman

Project No. DR 5 Amount of Grant: (Included in DR 12 total $5,000)

SUMMARY OF WORK

A final summary report on this project was presented at the last meeting of the Associate Committee in October, 1947.

At that time it was suggested that the final report be suitably revised and edited for publication in a dental periodical. This paper has been prepared and has been submitted to the Publications Panel.

Further investigations are being conducted on subjects closely allied to DR 5 under a new project, DR 21.

February,
1 9 4 8 .

APPENDIX "F"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: The development of culture technique for certain fungus-like organisms found in periodontal disease.

Grantee: C.H. Best

Project No. DR 16 Amount of Grant: $1,100

SUMMARY OF WORK

We have been concerned in this study with the cultivation of the organism, Leptothrix falciformis which is found in deep pockets in periodontal diseases.

Efforts have been made to culture the organism by alteration of nutritional requirements and environmental conditions; and some stress has been placed upon the addition of essential nutritional elements and nutrilites to artificial culture media, but no success has been obtained. More work must be done along the lines of nutritional element studies. Such studies have been planned along with proposed investigations on "in vivo" experiments on the development of the organism in surgically produced periodontal disease in dogs.

Through preliminary experiments on dogs we have been able to show that by artificially producing periodontal disease, a direct study of the development of the Leptothrix falciformis organism can be made.

Beginning with a sterile pocket, brought about through surgery and the use of cement pack, a day to day study has been carried out on a small number of dogs. We have been able to follow, to a degree, the life cycle of the organism as outlined by Beust and Aisenberg. It is hoped that more comprehensive information will be obtained about the organism when a larger number of animals has been used.

February,
1 9 4 8 .

APPENDIX "F"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

APPENDIX "G"

SUMMARY OF FINAL REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

1. Subject — The Experimental Production of Dental Caries in Vitro.

2. Authors — H. K. Box, D.D.S., Ph.D., and R.A. Hugill, D.D.S.

3. Project No. — DR 18

4. Purpose

To artificially produce a caries lesion to meet the microscopical qualifications of the true caries picture.

5. Scope

The experimental work was carried out under four phases or combination of phases:-

(a) Acid phase

(b) Enzyme phase

(c) Acid - Enzyme phase

(d) Bacterial phase

A. Acid Phase

Various acids were used to observe the action of acids on enamel and dentin.

Observations and Conclusions

1. Acid decalcifies enamel structure.

2. Acids appear to produce cross-striation of the enamel.

3. Acids appear to destroy interprismatic substance.

4. Acids may be responsible for translucency produced in enamel.

5. Various acids at the same pH. do not have the same rate of decalcification of enamel. This would bring one to believe that the kind of acid and the concentration are more significant in decalcification than the pH. of the acid.

6. Acid produces a translucent and clear homogenous mass in decalcified dentin.

7. Partially decalcified enamel either in the early lesion or on the advancing border of the late lesion may or may not show up in an X-ray.

B. Enzyme Phase

The action of pepsin and papain enzymes were observed on enamel.

Observations and Conclusions

1. Pepsin enzyme or a similar proteolytic enzyme may be responsible for the pigmentation in a carious lesion.

2. This enzyme (pepsin) may aid in destroying the highly organic cortical enamel layer.

3. Papain enzyme appears to be inert.

C. Acid-Enzyme Phase

Three experiments were carried out in this phase.

1. Teeth were placed in a combined solution of Pepsin enzyme and Lactic acid.

2. Teeth were placed first in acid for 45 days and then in enzyme for 45 days.

3. Teeth were placed first in acid for 24 hours and then in enzyme for 24 hours and alternated for 70 days.

Observations and Conclusions

1. Lactic Acid and Pepsin enzyme, both in one solution appear to produce a lesion similar in most respects to the true carious lesion.

2. Acid and Enzyme work most satisfactorily simultaneously to produce a carious effect.

D. Bacterial Phase

Three experiments were carried out.

1. Teeth were placed in an incubated mush of whole wheat flour and distilled water for 50 days.

2. Bacteria from whole wheat flour were incubated in sugar solutions and tests for various acids were made and smears of the broths taken.

3. Bacteria from whole wheat flour were placed in sugar solutions and incubated for an indefinite period. Teeth were added to the solutions.

Observations and Conclusions

1. Whole wheat bacteria are acid producing organisms.

2. These bacteria produce various acids in sugar solutions by enzyme action.

3. Microscopical evidence would indicate that the bacteria liberate proteolytic enzymes as well as acids. This would indicate that two types of bacteria are not necessary to produce a carious lesion.

4. Microscopically these bacteria are short rod and cocci organisms.

5. These organisms are capable of producing a lesion in enamel and possible in dentin.

Feb. 23, 1948.

APPENDIX "G"

FINAL REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

I. Subject: The experimental production of dental caries in vitro.

II. Grantees: Dr. H.K. Box and Dr. R.A. Hugill

III. Project No.: DR 18

IV. Purpose: To produce artificially a caries lesion to meet the microscopical qualifications of the true caries lesion.

AMONG THE CHANGES CHARACTERISTIC OF CARIES OF THE ENAMEL ARE THE FOLLOWING, (see figure 1 of true caries picture)

1. Pigmentation - On approximal surfaces, a band of darkly pigmented material is frequently observed on the border of the advancing carious lesion. This band varies in width. This change has been interpreted in different ways, and it has been stated that it does not occur in pulpless teeth and cannot be produced artificially. Also, the involved enamel in some cases shows yellowish and brownish pigmentation in the carious lesion.

2. Transverse Striation - The enamel prisms show marked transverse striae and this is commonly regarded as a result of the action of acids.

3. Destruction of the interprismatic substance with the formation of minute spaces between the enamel rods.

4. Granulation and pigmentation of the prisms.

5. Translucent enamel, apparently produced by acid action.

Certain changes in the dentin in caries, (see figure 1)

1. Yellow pigmentation of the dentin at the base of the lamellae and in frontal caries lesions, at the dento-enamel junction.

2. Dentin shrinkage at the dento-enamel junction beneath carious lesions in the enamel.

3. Translucent dentin underneath zones of yellow pigmentation.
4. Rod-shaped fragments and granules in the dentinal tubules frequently observed just beyond the advancing caries.

APPENDIX "G"

FINAL REPORT TO THE ASSOCIATES COMMITTEE ON DENTAL RESEARCH

I. Subject: The experimental production of dental caries in vitro.

II. Grantees: Dr. R.E. Box and Dr. R.A. Hueglli

III. Project No.: DR 12

IV. Purpose: To produce artificially a caries lesion to meet the microscopical qualifications of the true caries lesion.

AMONG THE CHANGES CHARACTERISTIC OF CARIES OF THE ENAMEL ARE THE FOLLOWING. (see figure 1 of true caries picture)

1. Pigmentation - On approximal surfaces, a band of darkly pigmented material is frequently observed on the border of the advancing carious lesion. This band varies in width. This change has been interpreted in different ways, and it has been stated that it does not occur in oxalgese teeth and cannot be produced artificially. Also, the involved enamel in some cases shows yellowish and brownish pigmentation in the carious lesion.

2. Transverse Striation - The enamel prisms show marked transverse striae and this is commonly regarded as a result of the action of acids.

3. Destruction of the interprismatic substance with the formation of minute spaces between the enamel rods.

4. Granulation and pigmentation of the prisms.

5. Translucent enamel, apparently produced by acid action.

Certain changes in the dentin in caries. (see figure 1)

1. Yellow pigmentation of the dentin at the base of the lamellae and in frontal caries lesions, at the dento-enamel junction.

2. Dentin shrinkage at the dento-enamel junction beneath carious lesions in the enamel.

3. Translucent dentin underneath zones of yellow pigmentation.

4. Rod-shaped fragments and granules in the dentinal tubules frequently observed just beyond the advancing caries.

V. Methology and Scope:

General Methology

1. Non-carious teeth, as far as can be detected macroscopically, are carefully selected, preferably anterior and bicuspid teeth. The teeth were first auto-claved, washed and scrubbed, and then placed in anti-bacteriocidal solution for a period of approximately 7 days before using.

2. The teeth are covered with a coat of paraffin wax, and on the labial or buccal surface of the crown, a window is cut to expose a given area of enamel surface.

3. After specific treatment, ground sections of the teeth were prepared and mounted with Canada balsam for microscopical study.

A. Acid Phase Experiments

By the action of acids and acid buffers, Enright and Friesel claimed to produce a lesion which simulated the natural caries lesion in enamel and dentin. However, on employing the same methology to duplicate this artificial lesion produced by Enright and Friesel, a lesion was produced which appears similar to the lesions illustrated in their photographs, (1) but appears to lack some of the important microscopical characteristics of the true dental caries picture.

Experiment 1.

Methology: Paraffin prepared teeth were placed in the following acid solutions:

1. Lactic
2. Citric
3. Tartaric
4. Succinic
5. Pyruvic
6. Butyric
7. Acetic
8. Phosphoric
9. Malic
10. Propionic
11. Formic

(1) J.A.D.A. Vol. 20 June 1933, No. 5, p. 897

V. Methodology and Scope:

General Methodology

1. Non-carious teeth, as far as can be detected macroscopically, are carefully selected, preferably anterior and bicuspid teeth. The teeth were first auto-clared, washed and scrubbed, and then placed in anti-bacterioidal solution for a period of approximately 7 days before using.

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Experiment I.

Methodology: Paraffin prepared teeth were placed in the following acid solutions:

1.	Lactic	7.	Acetic
2.	Citric	8.	Phosphoric
3.	Tartaric	9.	Malic
4.	Succinic	10.	Propionic
5.	Pyruvic	11.	Formic
6.	Butyric		

(1) J.A.D.A. Vol. 20 June 1933, No. 6, p. 997

The acids are 1% solutions in distilled water and buffered with 1% sodium hydroxide solution to a pH.4.5. The solutions and bottles were boiled to destroy possible contaminating bacteria. The solutions were changed every 2 to 3 days.

The teeth were immersed in the acid solutions for a period of 45 days. X-rays were taken (exposure time 6 secs.), of the teeth at the end of 12, 26 and 45 days.

Results of Experiment

The actions of two acids - lactic and citric, will be used for descriptive purposes representing the overall picture of this experiment.

Lactic acid

(a) Radiographic Examination - At the end of 12 days, decalcification of the tooth structure over the window, cast a radiographic shadow 1/3 of the way through the enamel; at the end of 26 days, ½ way through the enamel; and at the end of 45 days, had penetrated about 1½ mm. into the dentin.

(b) Microscopical Examination - At the end of 45 days the acid decalcification process had penetrated slightly into the dentin. Most of the decalcified enamel over the window had been lost through grinding the section. Along the sides of the window can be seen decalcified rods, bearing resemblance to cross-striation. Part of the remaining decalcified enamel over the base of the window had a homogenous appearance with cross-striation. The interprismatic spaces or interod spaces appear to be very translucent, demonstrating penetration of acid down between the rods. The zone of decalcified dentin near the dento-enamel junction is translucent and homogenous with loss of definite outline of the dentinal tubules.

Citric Acid

(a) Radiographic Examination - At the end of 12 days, the acid decalcification process cast a radiographic shadow ¼ of the way through the enamel; at the end of 26 days, ½ of the way through the enamel; and at the end of 45 days, the radiographic shadow penetrated approximately 1½ mm. into the dentin.

(b) Microscopical Examination - The acid decalcification process penetrated through the enamel and slightly into the dentin over the window. In the window, all of the decalcified enamel was lost in sectioning the tooth. The outline of the dento-enamel junction is visible. The decalcified dentin still remained intact. The outline of the dental tubules still were

apparent about ½ of the way into the decalcified mass of dentin. However, the decalcified dentin zone above, next to the dento-enamel junction, appears to be quite homogenous and structureless. Decalcification appears to be proceeding down the dentinal tubules and between them.

Lactic, citric, pyruvic and acetic acids decalcify enamel at about the same rate. Tartaric, phosphoric, malic and formic acids decalcify a little slower, and the decalcification produced by Butyric, succinic, and propionic acids is quite slow.

Experiment 2.

Methology: Paraffin prepared teeth were placed in 100 cc. of 1% lactic acid pH. 4.5 to which 1 gram of sodium chloride was added, for a period of 10 days.

Results of the Experiment

A slight penetration of acid decalcification into the enamel was observed, but it does not appear any different from a ground section of a tooth decalcified by lactic acid for 10 days without the addition of Sodium Chloride.

Experiment 3.

Methology: Paraffin prepared teeth were placed in a 1% solution of Lactic Acid buffered with 1% Sodium Hydroxide to pH. 4.5 for a period of 20 days. The teeth were removed, X-rayed, and placed in a methylene blue dye for 48 hours.

Results of the Experiment

(a) Radiographic Examination - The decalcification process appears to penetrate approximately ½ way through the enamel.

Macroscopical examination of the section before it was ground thin shows blue stain almost to the dento-enamel junction.

(b) Microscopical Examination - Shows blue stain penetrating only slightly into the base of the decalcified zone. The blue stain that appears to be present in the section on macroscopical examination before finishing, was either washed out during the grinding process or else was only surface stain on the section.

B. Enzyme Phase Experiments

Experiment 1.

Methology - Paraffin prepared teeth were immersed in the following prepared pepsin and papain enzyme solutions:

(a) Pepsin 5% solution, pH.4.0.

(b) Pepsin 5% solution, buffered with 1% Sodium Hydroxide to a neutral pH.7.0.

(c) Papain 5% solution, pH.4.0.

(d) Papain 5% solution, buffered with 1% Sodium Hydroxide to a neutral pH.7.0.

Thymol crystals were added to eliminate bacterial action. The teeth were left immersed in the solutions for a period of 4 months.

Results of the Experiment

Pepsin enzyme pH.4.0 produced a slight surface decalcification, although macroscopically before grinding the surface, appeared and felt mechanically hard and intact. Pigmentation of the enamel surface below the window was fairly intense, acquiring an orangy yellow colour. However, other areas near the enamel surface showed pigmentation and surface decalcification as well. A possible explanation is that the enzyme had worked its way under the paraffin coat which covers the tooth other than over the window.

Pepsin enzyme is an organic solvent. It is believed that the cortical enamel layer is of highly organic substance. This may be the reason for the uniform surface decalcification of the enamel by the enzyme.

Pepsin enzyme buffered to a neutral pH.7.0 produced a picture not unlike the pepsin solution whose acid pH. was 4.0. This would lead us to believe that it was the proteolytic properties possessed by pepsin to dissolve or break down organic material that caused the surface decalcification of the cortical enamel, rather than the relative pH. of the solutions.

Papain enzyme proved to be rather inert as an active proteolytic enzyme on the enamel of a tooth.

B. Enzyme Phase Experiments

Experiment 1.

Methodology - Paraffin prepared teeth were immersed in the following prepared pepsin and papain enzyme solutions:

(a) Pepsin 5% solution, pH.4.0.

(b) Pepsin 5% solution, buffered with 1% Sodium Hydroxide to a neutral pH.7.0.

(c) Papain 5% solution, pH.4.0.

(d) Papain 5% solution, buffered with 1% Sodium Hydroxide to a neutral pH.7.0.

Thymol crystals were added to eliminate bacterial action. The teeth were left immersed in the solutions for a period of 4 months.

Results of the Experiment

C. Acid Enzyme Phase Experiments

Experiment 1.

Methology: Paraffin prepared teeth were placed in a mixture of the following acid-enzyme combined solutions:

(a) Lactic Acid 1% solution, buffered with 1% solution of Sodium Hydroxide to an acid pH.4.5, was mixed with a 5% solution of Pepsin enzyme pH. 4.0.

(b) Lactic Acid 1% solution, buffered with 1% solution of Sodium Hydroxide to an acid pH.4.5, was mixed with a 5% solution of Papain enzyme pH.4.0.

Thymol crystals were added to eliminate any bacterial action. The teeth were immersed for periods ranging from 70 to 90 days.

Results of the Experiment

(a) Lactic Acid - Pepsin Enzyme Combination: See figures 2 to 7 and compare observations to figure 1 of a true caries picture.

The changes produced artificially characteristic of caries of the enamel are the following:

(1) Pigmentation - A darkly pigmented (orangy yellow) band can be seen in advance of the carious lesion. See figures 2,3,4,5.

(2) Transverse Striation - These are cross striae seen on the enamel prisms in the artificial carious lesion. See figures 2,3,4,5.

(3) Destruction of the interprismatic substance with minute spaces between the enamel rods. See figures 2,3,4,5.

(4) Granulation and pigmentation of the enamel prisms. See figures 3,4,5.

(5) Transparent enamel. See figure 2,4.

The changes produced artificially characteristic of certain changes in the dentin in caries are the following:

(1) A yellowish orange pigmentation of the dentin below and at the dento-enamel junction. See figures 3,4,5. This appears microscopically the same as in the true carious lesion in figure 1.

C. Acid Enzyme Phase Experiments

Experiment I.

Methodology: Paraffin prepared teeth were placed in a mixture of the following acid-enzyme combined solutions:

(a) Lactic Acid 1% solution, buffered with 1% solution of Sodium Hydroxide to an acid pH.4.5, was mixed with a 5% solution of Pepsin enzyme pH. 1.0.

(b) Lactic Acid 1% solution, buffered with 1% solution of Sodium Hydroxide to an acid pH.4.5, was mixed with a 5% solution of Papain enzyme pH.8.0.

Thymol crystals were added to eliminate any bacterial action. The teeth were immersed for periods ranging from 70 to 90 days.

Results of the Experiment

(a) Lactic Acid - Pepsin Enzyme Combination: See figure 2 to 7 and compare observations to figure 1 of a true caries picture.

The changes produced artificially characterization of caries of the enamel are the following:

(1) Pigmentation - A darkly pigmented (brown,yellow) band can be seen in advance of the carious lesion. See figure 2,3,4,5.

(2) Transverse Striation - These are cross stripe seen on the enamel prisms in the artificial carious lesion. See figure 2,3,4,5.

(3) Destruction of the interprismatic substance with migute spaces between the enamel rods. See figures 2,3,4,5.

(4) Granulation and pigmentation of the enamel prisms. See figures 3,4,5.

(5) Transparent enamel. See figure 2,4.

The changes produced artificially characteristic of certain changes in the dentin in caries are the following:

(1) A yellowish orange pigmentation of the dentin below and at the dento-enamel junction. See figures 2,3,5. This appears microscopically the same as in the true carious lesion in figure 1.

(2) Dentin shrinkage at the dento-enamel junction beneath the carious lesion in the enamel. See figure 5.

(3) Transparent dentin underneath the zone of yellow pigmentation. See figures 5,7.

(4) Rod shaped fragments and granules in the dentinal tubules beyond the advancing carious lesion. See figures 4,6.

(b) Lactic Acid - Papain Enzyme Combination produces no changes microscopically at all on the surface of the enamel and appears to be inert in this combination.

Experiment 2.

Methology: Paraffin prepared teeth were placed in a 1% solution of Lactic Acid, buffered with 1% solution of Sodium Hydroxide to pH.4.5, for a period of 24 hours then removed, washed in distilled water, and then immersed in enzyme solutions. (a) pepsin 5% solution; (b) papain 5% solution for the next 24 hours. This process was alternated in the acid and enzyme solutions for a period of 70 days. Thymol crystals were added to the solutions to eliminate bacterial action. Fresh solutions were prepared at intervals.

Results of the Experiment

(a) Lactic Acid and Pepsin Enzyme Combination - The changes produced artificially characteristic of caries of the enamel are the following.

(1) Cross-striation of the decalcified enamel prisms.

(2) A dark brownish orange pigmented band in advance of the carious lesion in the enamel.

(3) Destruction of interprismatic substance.

(4) Dark brownish orange granulation and pigmentation of the affected enamel prisms.

There were no changes produced in the dentin as the artificial lesion had advanced only $\frac{3}{4}$ of the way to the dento-enamel junction.

(b) Lactic Acid and Papain Enzyme Combination - Papain enzyme appears to be inactive and only changes produced by acid decalcification were present.

Experiment 3.

Methology: Paraffin prepared teeth were immersed in 1% solutions of the following acids buffered to pH.4.5 with 1% solution of Sodium Hydroxide for a period of 45 days.

1. Lactic
2. Citric
3. Tartaric
4. Succinic
5. Pyruvic
6. Butyric
7. Acetic
8. Phosphoric
9. Malic
10. Propionic
11. Formic

Then the teeth were removed, and placed in 5% solutions of (a) pepsin, (b) papain enzymes for an indefinite period. Thymol crystals were added to eliminate bacterial action. Fresh solutions were prepared at intervals.

Results of the Experiment

(a) e.g. Lactic Acid and Pepsin Enzyme

The changes produced artificially characteristic of enamel caries were the same as those produced in experiments 1 and 2 except that there was very little pigmentation of the enamel in advance of the carious lesion. However, the decalcified enamel prisms did show some granulation and pigmentation.

The changes produced artificially characteristic of dentin caries were nil. There was no pigmentation, and no shrinkage of the dentin at the dento-enamel junction. For a short distance into the dentin, there was a transparency, and loss of structure.

(b) Papain enzyme appears to be inert, only changes produced by acids were present.

Experiment 4.

Methology: Paraffin prepared teeth were immersed in a Lactic Acid 1% solution buffered with 1% Sodium Hydroxide to pH.4.5 for 30 days, removed and placed in 5% solutions of (a) pepsin, (b) papain enzymes for 30 days. Then the teeth were removed, X-rayed, and placed a silver nitrate dye for 48 hours.

Results of the Experiment

(a) Lactic Acid and Pepsin Enzyme

(i) Radiographic Examination. A light radiographic opacity was shown penetrating $\frac{3}{4}$ of the way through the enamel. This is evidence of the absorbtion of the silver salt, into the acid-enzyme affected area in the enamel.

(ii) Microscopical Examination. Various degrees of dark coloration ranging from yellow to black were shown in the affected area in the enamel, due to the absorbtion of the silver salt from the dye. The decalcification and proteolytic process appeared to have advanced approximately $\frac{3}{4}$ of the way through the enamel.

Just to one side of the main part of the window, a lamella in the enamel was stained black, running from the surface of the enamel remaining intact to the dento-enamel junction, and balling out below the junction, characteristic of lamellae caries, but this too was stained black by the absorbtion of the silver salt.

(b) No observations for the Lactic acid - Papain enzyme combination.

D. Bacterial Phase Experiments

Experiment 1.

Methology: Paraffin prepared teeth were placed in a mush of whole wheat grain flour and distilled water for a period of 50 days. A smear was taken of the mush and stained with methylene blue.

Results of the Experiment

The action of the bacteria on the enamel is quite pronounced, producing the following: See figure 8.

(1) A lesion simulating in outline to frontal caries.

(2) Cross-striation of the enamel prisms.

(3) Disorganization of the enamel prisms.

(4) Destruction of interprismatic substance between the enamel rods.

(5) Transparency of the enamel.

(6) Slight pigmentation in advance of the decalcified area in the enamel.

The lesion was confined to the enamel and if carried on to a later stage, dentin changes would likely be produced.

The smears showed quite a number of short rod bacteria and an abundance of cocci organisms.

Experiment 2.

Methology: Cultures of bacteria, obtained by incubating whole wheat grain flour in distilled water for 3 days, were inoculated into 20% solutions of the following sugars:

1. Dextrose
2. Galactose
3. Maltose
4. Sucrose

and a 1% solution of cooked starch. Into these solutions were placed paraffin prepared teeth and left for an indefinite period.

Results of the Experiment

All of the results from this experiment have not been tabulated as yet.

Using dextrose sugar and whole wheat bacteria, a lesion was produced in the enamel. Cross striation of the enamel prisms, destruction of interprismatic substance, pigmentation and granulation in the enamel prisms were all present. In most respects it appeared to be the same microscopically as the lesion produced in the enamel by lactic acid and pepsin enzyme in solution together.

Experiment 3.

Methology: Cultures of bacteria obtained from incubating whole wheat grain flour in distilled water for 3 days, were inoculated into 20% solutionsof dextrose, galactose, maltose and sucrose sugars and a 1% solution of cooked starch. These solutions were incubated until the pH. of the solution rose to a pH. of 4.5 and then were tested for the presence of the following acids: lactic, succinic, malic, tartaric, pyruvic, formic and citric. Also smears of each broth were taken and stained with methylene blue.

Tests for Acids Used

Lactic Acid - Uffelmann's

Succinic Acid - On gently heating a mixture of saturated aqueous succinic acid and an aqueous suspension of calcium salicylate, a persistant red rose colour develops.

Malic Acid - Similarly treated as succinic above, gives only an unstable rose colour which on gently boiling for 15-20 minutes gradually disappears.

Tartaric Acid - To a solution of Tartaric acid, add a little ferrous sulphate, two drops of hydrogen peroxide and an excess of alkali. A pale violet colour is produced.

Formic Acid - A yellowish-red colour develops on warming a solution containing formic acid with 15 drops of a 50% sodium bisulphite solution.

Pyruvic Acid - Treat the pyruvic acid with ammonia, then some sodium nitroprusside solution and heat gently. A blue violet colour forms which changes to orange on long standing.

Citric Acid - Reagent: A solution of 0.02 gm. of B napthol in 1 cc. of concentrated H_2SO_4. Test: to about 0.05 gm. of the substance to be tested add 10-15 drops of the reagent and cautiously heat the mixture over an open flame. Citric acid gives a blue melt which dissolves in water without colour.

Acetic Acid - If ferric chloride is added to a neutral solution of an acetate, a red colour is produced. The colour is discharged by the addition of dilute hydrochloric acid.

Results of the Experiment

Acid Tests are as follows:

	Succinic	Malic	Lactic	Tartaric	Pyruvic	Formic	Acetic	Citric
Dextrose	- ve	- ve	+ ve	+ ve	+ ve	- ve	- ve	+ ve
Starch	- ve	+ ve	+ ve	- ve	+ ve	- ve	- ve	- ve
Galactose	+ ve	- ve	+ ve	- ve	- ve	- ve	- ve	- ve
Sucrose	- ve	- ve	+ ve	- ve	+ ve	- ve	- ve	- ve
Maltose	- ve	- ve	+ ve	- ve	- ve	- ve	- ve	- ve

Description of Smears: All of the sugar and starch solutions exhibited an abundance of organisms in the smears. The chief type found were cocci bacteria, and closely related short rods were in large numbers. A very few structures resembling threadlike organisms were seen,

Summary and Conclusions of the Experimental Phases:

(a) Acid Phase

1. Acid decalcifies enamel structure.

2. Acids appear to produce cross striation of the enamel prisms.

3. Acids appear to destroy interprismatic substance.

4. Acids may be responsible for translucency produced in enamel.

5. Various acids at the same concentration and pH. do not have the same rate of decalcification of enamel. This would bring one to believe that the kind of acid and the concentration are more significant in decalcification than the pH. of the acid.

Results of the Experiment

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	Succinic	Malic	Lactic	Tartaric	Pyruvic	Formic	Acetic	Citric
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Starch	- ve	+ ve	+ ve	- ve	+ ve	- ve	- ve	- ve
Galactose	+ ve	- ve	+ ve	- ve	- ve	- ve	- ve	- ve
Sucrose	- ve	- ve	+ ve	- ve	+ ve	- ve	- ve	- ve
Maltose	- ve	- ve	+ ve	- ve	- ve	- ve	- ve	- ve

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6. Acid produces a translucent and clear homogeneous mass in acid decalcified dentin.

7. Partial decalcified enamel either in the early lesion or on the advancing border of the late lesion may or may not show up in an X-ray.

(b) Enzyme Phase

1. Pepsin enzyme or a similar proteolytic enzyme may be responsible for the pigmentation in a carious lesion.

2. This enzyme may aid in destroying the highly organic cortical enamel layer.

(c) Acid-Enzyme Phase

1. Lactic acid and pepsin enzyme, both in one solution appear to produce a lesion similar in most respects to the true carious lesion.

2. Acid and enzyme work most satisfactorily simultaneously to produce the carious effect. Failure in experiment No. 3 in this phase in which teeth were placed in acid for 45 days and then in enzyme in attempt to produce a lesion, may be explained by the fact that the decalcified inorganic salts freed by the acid action may have built up an inorganic barrier to the penetration of enzyme proteolysis.

3. Decalcification and proteolysis may or may not penetrate farther than interpreted by radiographic diagnosis.

(d) Bacterial Phase

1. Whole wheat bacteria are acid producing organisms.

2. In various sugar solutions these bacteria are capable of producing various acids by enzyme action.

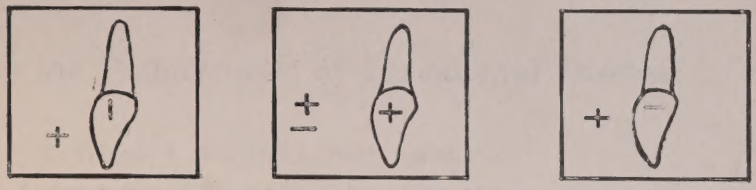
3. Microscopical evidence would indicate that the bacteria liberate proteolytic enzymes as well - see pigmentation in experiment 1. This would indicate that two groups of organisms are not necessary to produce a carious lesion.

4. Microscopically these bacteria are specifically cocci and short rod organisms.

5. These organisms are capable of producing a lesion in enamel and possible in dentin.

VII. Evaluation Artificial Caries - Producing Mechanism:

1. To carry out controlled experiments



+ in solution represents the caries producing mechanism

+ in the tooth represents a normal tooth

- in solution represents an anti-caries mechanism

- in tooth represents a protective mechanism in the tooth, such as fluorine treated teeth.

2. To determine possibly the difference in susceptibility in various parts of the mouth e.g. immunity of the lower anterior teeth.

3. To determine the difference in susceptibility of deciduous teeth to permanent teeth and young permanent to aged permanent teeth.

4. To determine a diagnostic co-relation of early caries production to the radiograph.

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Concerning the Pathogenesis of Periodontal Disease

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Concerning the Pathogenesis of Periodontal Disease*

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INTRODUCTION

THE dental literature is replete with contradictory viewpoints relating to the etiology and pathology of periodontal disease. Investigators have been classed as localists, or those who held that extrinsic factors are all important, and constitutionalists, or those who took the stand that systemic disturbances are wholly responsible. Then again, much argument has centered on the problem of the site of the initial, or so-called primary, lesion. The gingival tissues, the alveolar bone, and the periodontal membrane for many years have had their advocates in this regard. Even within a certain group, while opinions may agree on the site, they may disagree on the source of the etiologic factor**. It would be fruitless, at this time, to discuss these diverse and varied viewpoints at any length†. Many of the early investigators, in attempting to establish a common theory, failed to distinguish between two clinically different and commonly observed types of periodontal disease. Hence, the findings are frequently applicable only to one or the other type.

These types, under various nomenclatures, are so well recognized today that only certain features having a special bearing on our problem will be mentioned at this time. In the first type, gingival inflammation is clinically conspicuous, the pockets tend to develop in a broad and shallow manner and the progress of the disease is slow. Increased mobility of the tooth in its alveolus is relatively a late sign. Essentially, the condition is a progressive gingivitis. This is a Simplex Periodontitis.

In the second type, in its purest form, the gingival tissues show little inflammation clinically. In fact, they may appear at times almost normal, or pale and thin with little tendency towards recession in the earlier stages. The progress of the disease may be rapid. The involved teeth in certain situations are prone to displacement, and diastema may form. The pockets usually tend to develop narrowly and deeply along the root surface, but at times may show an early tendency to widen and encircle the root. Tooth mobility frequently is an early sign. This is a Complex Periodontitis.

It should be mentioned that the dentist is often confronted with cases which are not so sharply defined as these basic types. It is obvious that cases are to be seen which represent admixtures and variations of the fundamental processes concerned. In the second type, for example, the presence of calculus, both subgingival and supragingival, tends to intensify the gingival inflammation, thus helping to obscure the primary process. Under certain conditions, the phenom-

*Read by Dr. C.H.M. Williams before the Amercian Academy of Periodontology, Aug. 2, 1947, *Boston, Massachusetts.*

**For example, Witzel of Germany believed that the initial lesion occurred in the bone crest and regarded the process as entirely local and not dependent on disturbed systemic conditions. Roy of France also concluded that the bone lesion was primary but, on the other hand, considered that the process was brought about by constitutional factors. Local causes were regarded as of secondary importance.

†For a comprehensive review of the subject see Bunting and Hill *(Oral Pathology,* Lea & Febiger, 1940).

ena of recession and cleft formation in the gingival tissues enter the clinical picture. It is now apparent that the importance of Stillman's Clefts*, especially in their relation to the deeper structures, has not been fully appreciated in periodontal pathology.

THE ROLE OF INFLAMMATION IN PERIODONTAL DISEASE

As would be expected, the role of inflammation in periodontal disease from the viewpoint of the microscope has been the center of much discussion in recent years. A great deal of the argument regarding the site of a common primary lesion has involved the relationship of gingival inflammation to the underlying bone, as variously observed by different investigators.

The expressed views of a number of workers have not been in agreement in regard to the course of invasion of the supporting tissues of the teeth by inflammatory processes originating in the gingival tissues. However, the accumulated evidence on this problem points to several features of great significance. The first is the relative freedom of the periodontal membrane from inflammatory reaction, as marked by cellular infiltration of gingival origin (Fleischmann and Gottlieb, 1921; James and Counsell, 1927; Box, 1928; and Weinmann, 1941). The second is the tendency of the inflammatory cellular infiltration to involve the bone marrow (James and Counsell, 1927; Box, 1928; and Weinmann, 1941).

Recently, Weinmann (1941) reviewed the subject of the progress of gingival inflammation, and following an extensive histological investigation presented a summary of his findings. These are in substantial agreement with those of the English workers James and Counsell, who reported their findings in 1927. The inflammatory infiltration follows the course of the blood vessels through the gum corium to the crest and periosteal side of the bone. With resorption of the bone, it progresses into the bone marrow. The periodontal membrane is seldom involved by inflammatory cellular infiltration, and when this does occur, the process is one of extension from the bone marrow (Fig 1).

It is of interest to note that James and Counsell concluded that their observations on the pathways of extension of cellular infiltration did little to uphold the concept that lymphatics from the gingival tissues enter the periodontal membrane. It has been commonly accepted that cellular infiltration marks the course of the lymphatics when these vessels are transporting toxic substances such as bacterial toxins.

One manifest conclusion from the foregoing evidence is that inflammation of the periodontal membrane, as marked by cellular infiltration, cannot be held responsible for early and rapid loosening of the tooth in periodontal disease.

It should not be forgotten that inflammation is a defensive process initiated in the tissues by injury, and, as Adami (1910) has

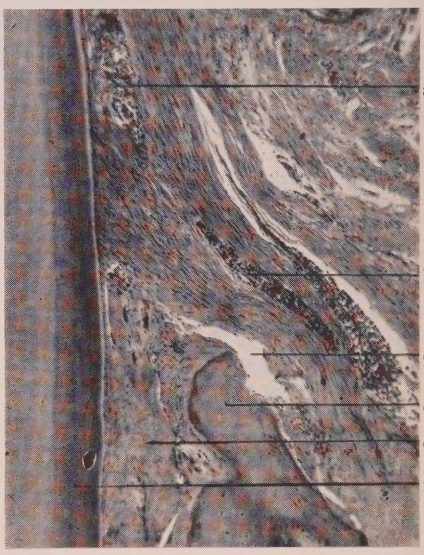

Fig. 1. Pathway of extension of inflammatory cellular infiltration from the gingival tissue over the alveolar crest. Note absence of this small cell infiltration in the periodontal membrane. (Biopsy material.) a. Inflammatory cellular infiltration in gingival tissue; b. cellular infiltration extending over periosteal side of alveolar crest; c. shrinkage artefact; d. alveolar crest; e. periodontal membrane; f. cementum.

*Stillman's Clefts are fissures which occur in the gingival tissues. They extend inwards from the gingival margin along the pocket wall, and outwards to involve the gingival surface for varying distances. The surface defect may appear as a very fine groove which may be fairly straight or curved, and may terminate, fork-like, in two branches.

pointed out, "all means are employed to antagonize the irritant and to effect healing". It is known that enzyme-inhibiting substances are present in the serum of inflammatory exudates (Opie, 1905; Wells, 1920). Thus, it may well be that one of the first defenses against enzyme penetration of the gingival tissues is operative in the pocket when inflammatory exudate is present.

The role of a necrotizing process in periodontal disease

Lymphatics are known to exist in the gingival tissues. Their presence in the periodontal membrane was first demonstrated by Schweitzer (1909). Noyes and Dewey (1918) confirmed this finding. According to these investigators, the lymphatic vessels from the connective tissue papillae of the labial or buccal, and lingual surfaces of the gingivae pass over the periosteal side of the bone. On the other hand, the lymphatics arising under the epithelium of the gingival sulcus pass inwards near the cementum surface and penetrate the alveolar crest group of fibers to enter the periodontal membrane. They accompany the blood vessels and nerves and extend in the indefinite connective tissue of Black.

Lymphatic capillaries are formed by thin, delicate endothelial cells and are readily observable in our ordinary microscopic preparations of the gingivae and periodontal membrane.

They are usually demonstrated by special staining methods, e.g., the injection of silver nitrate, or the Gerota mass. With the understanding that in the Dunlop Method of Insufflation the lymphatics are used for the carriage of oxygen to the tissues, we decided to use this method in an attempt to demonstrate lymphatics in the periodontal tissues of sheep. Various substances were employed by filling the sulcus and then insufflating with oxygen. When the dye, toluidin blue, was used, and under the special circumstance of air gaining access to the microscopic section under the coverslip, the lymphatic vessels were clearly demonstrated.

It is significant that, according to certain authorities (Maximow and Bloom, 1930; Drinker and Field, 1933), no lymphatic vessels have been found in the bone marrow.

Necrotic tracts in periodontal lesions

In certain cases of periodontal disease, the microscopic sections show fairly long tracts of disorganized tissue in the periodontal membrane. In the early stages, these tracts are homogeneous, and in their course may vary in width and sharpness of outline (Fig. 2). They may pursue a meandering course in the periodontal membrane (Fig. 3) and may approach the surface of the cementum and lie in close proximity to it for a considerable distance apically. The bone surface also may be involved, and the alveolar crest appears to be a region of predilection.

An example is shown in the next illustration where one of these tracts lies close to the cementum surface and adjacent to a nerve fiber and blood vessel (Fig. 4). It is known, of course, that lymphatics usually accompany the blood vessels and nerves.

We interpret these tracts as lymphatic vessels which appear to be distended with a curious coagulum-like material. Another reason, besides their propinquity to vascular structures, for assuming that these vessels are lymphatics, is the occasional presence of typical endothelial cells which follow the axis of the vessel-like tracts.

The loss of the endothelial lining and apparent damage of the adjoining connective tissue seems to be due to the action of a necrotizing agent transported by the lymphatic vessels. In this manner, the course of the involved lymphatics was readily delineated.

Evidence that these tracts are toxic is shown in the next illustration (Fig. 5) by their obvious effect on the cementoblasts. It is demonstrated here that in its course across the periodontal membrane, as the necrotic tract approaches the cementum and extends along its surface, the cementoblasts are lost. This is apparently due to a necrotizing action on these cells. It is to be noted also that there is no evidence of granulocytic reaction in the periodontal membrane, but this is no longer to be regarded as an absence of inflammatory reaction (Menkin).

When the necrotizing process is more extensive and larger regions of connective tissue are involved, the disorganization changes are more marked, as evidenced by the mild vacuolation of the involved tissue. This is

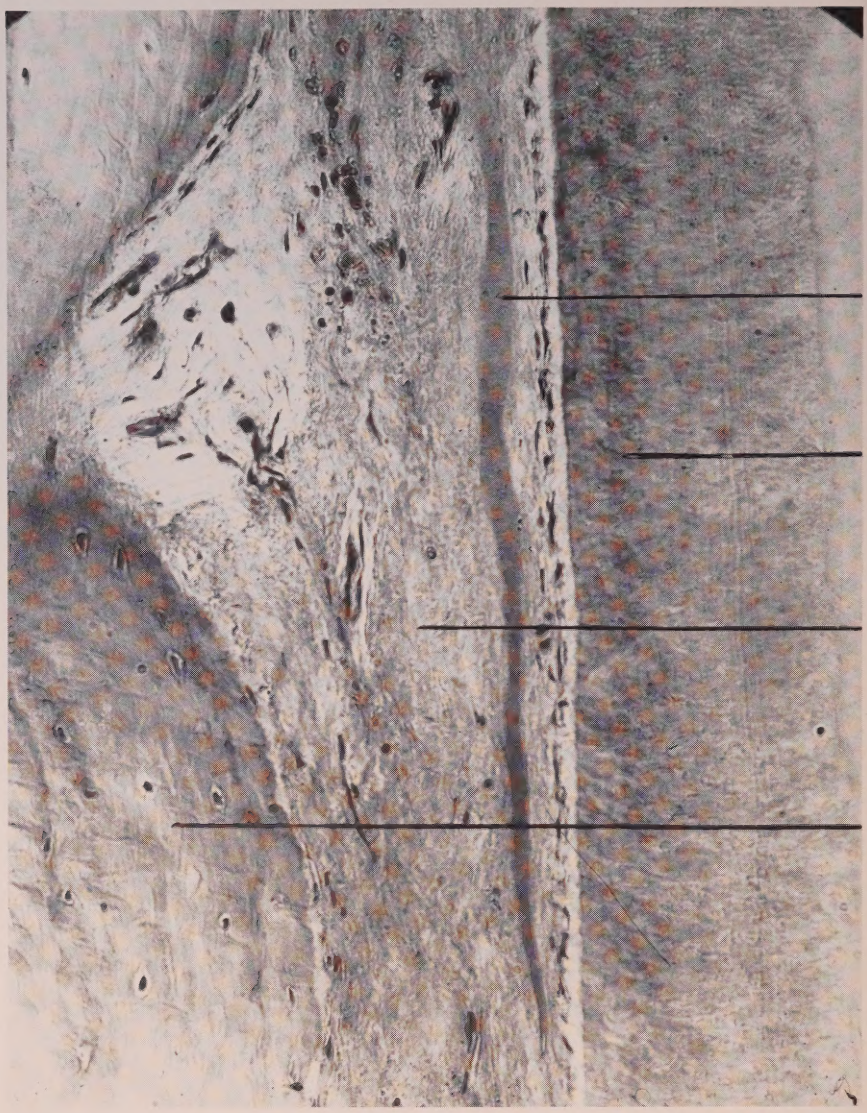

Fig. 2. Long necrotic tract in the periodontal membrane lying fairly close to the cementum surface. The lower end points apically. (Biopsy material.) a. Tract; b. cementum; c. periodontal membrane; d. alveolar bone.

well shown in the next illustration (Fig. 6). It is to be noted, also, that the cementum surface in contact with the necrotic tract is devoid of cementoblasts.

The next illustration (Fig. 7) shows destruction of the alveolar crest through the action of the necrotizing process. With loss of the osteoblasts, and decalcification of the

Fig. 3. Long meandering necrotic tract in the periodontal membrane. Note the mild vacuolation in certain regions. The lower extremity of the tract points apically. (Biopsy material.) a. Tract; b. cementoblasts; c. blood vessel; d. alveolar bone.

involved bone, the matrix has undergone vacuolation. Passing from the residue of the bone, a necrotic tract extends across the periodontal membrane to the tooth. It is to be noted that no small round cell infiltration is present.

Necrotic tracts extend from the base of the pocket into the deeper soft tissues. In our next illustration*, at the base of the separated epithelial attachment, the epithelial cells have undergone necrosis. Also, the connective tissue along the tract immediately below the necrotic epithelial attachment is markedly disorganized. Shrinkage artefact accentuates the course of the tract.

OTHER TRACTS ORIGINATING IN THE GINGIVAL TISSUES

Evidence of tracts having their origin in clefts in the gingival tissues and penetrating deeply into the supporting structures has been observed. The crest of the bone appears to be a site of predilection, and certain examples show the tract extending along the periosteal side of the bone for a considerable distance. Some of the tracts contain squames, epithelial implantation bodies, fungus-like organisms and countless coccoid bodies. There is no associated inflammatory cellular infiltration.

*Not shown in this paper.

EVIDENCE OF MORE SEVERE AND WIDE-SPREAD LESIONS

We shall now present some of the microscopic evidence of extremely severe lesions as represented by large spaces in the tissues*. These spaces lie in the cemental gingiva and extend laterally over the bone crest, and apically deep into the periodontal membrane. They are of various sizes and shapes and sometimes are alveolate in appearance. It will be observed, that in the region of the "focal lesion", the spaces are almost in contact with the base of the epithelial attachment. At one point, in one example, only one disorganized fiber bundle separates them. The term "focal lesion" is used here to indicate the center of greatest tissue damage. In all probability, it represents the site of the first attack and that from which the disease process has spread.

It will be observed at once that the disease process is not confined to the periodontal membrane, and in fact shows the greatest

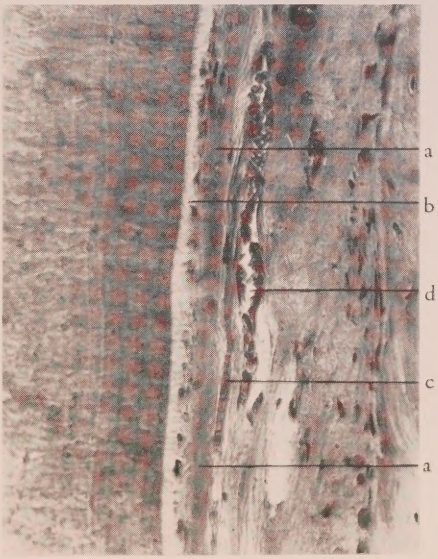

Fig. 4. Necrotic tract lying very close to the cementum surface and adjacent to nerve fiber and blood vessel. Note degeneration and loss of cementoblasts. (Biopsy material.) a. Tract; b. cementoid layer; c. nerve fiber; d. blood vessel.

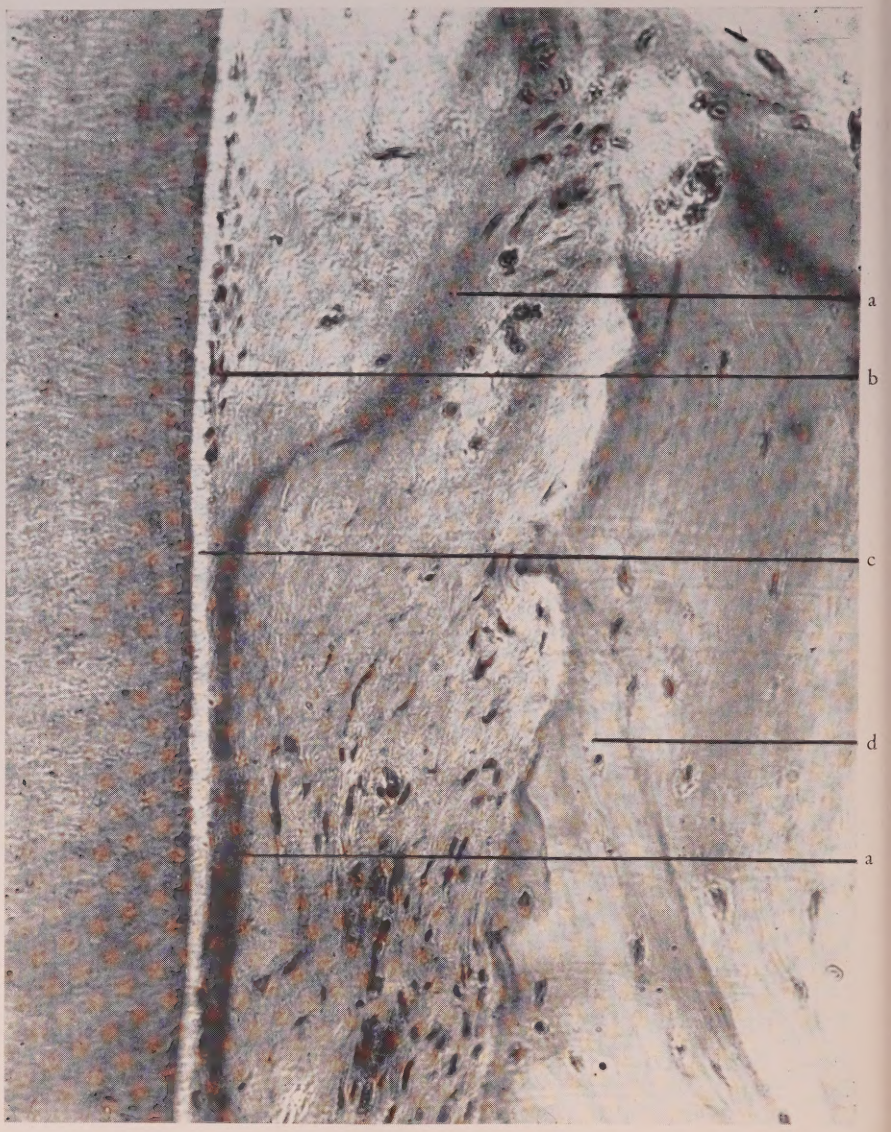

Fig. 5. This illustration shows a necrotic tract extending across the periodontal membrane to the cementum, and apically along the cementum surface. Note the absence of cementoblasts on the involved cementum surface. (Biopsy material.) a. Necrotic tract; b. cementoblasts; c. cementoid layer devoid of cementoblasts; d. alveolar bone.

degree of destruction in the soft tissues overlying the bone. The decreasing severity of the changes as the periodontal membrane is involved points to the unlikelihood of the primary lesion having had its origin in this structure.

As these spaces in the tissues afford little information as to the histopathology basically involved, valuable data in this regard may be obtained only by examining sections of regions at some distance from the "focal lesion". A study of serial sections shows that the disease is a spreading one, and apical and lateral extensions reveal certain details of the early changes.

The larger spaces are the result of the fusion of a number of large vacuoles which were originally filled with a homogeneous coagulum. This was lost in the preparation of the sections. In the more distant sites, the lesions are characterized by hemorrhage and the presence of this coagulum of unknown nature which stains pink with eosin-hematoxylin.

This coagulum tends to be vacuolated, and many red blood cells are to be seen lying on, or near, the borders of the larger vacuoles. Blood vessels are to be observed devoid of their endothelial lining, the red blood cells at times almost filling the vessel lumen. Throughout, the red cells are mainly intact. A conspicuous feature is the absence of inflammatory reaction as evidenced by cellular infiltration (Fig. 8; Fig. 9). Fibrous tissue remnants, in many regions, are still attached to the tooth, and, in one example, in the periodontal membrane, the coagulum fuses with the fibrous tissue, both on the tooth and on the bone. Here, one gains the impression that the blending is the result of fibrous tissue liquefaction.

Another feature to be observed is the disorganization which has occurred in the body of fiber bundles. The fibers show a hyaline-like change with mild vacuolation, which extends for some distance away from the tooth. They appear to be undergoing liquefaction. It is signficant that in the area of attachment to the cementum, no cementoblasts are present. Small vessels minus endothelium and containing red cells are to be noted in the midst of the disorganized fibers, and it seems apparent that a necrotizing agent was liberated in close proximity to these vessels (Fig. 10).

Fig. 6. Marked disorganization of periodontal membrane and alveolar crest. Note vacuolation of involved fibrous tissue in periodontal membrane and also of bone matrix at the crest border. (Biopsy material.) a. Extensive region of disorganization of fibrous tissue in periodontal membrane; b. bone crest apparently decalcified; c. vacuolation of crest border matrix; d. necrotic tract extending along cementum.

DISCUSSION

It may help to clarify matters at this point by stating our interpretation of these various findings. The mechanism seems to involve the production in the pocket of a necrotizing agent, and under certain conditions, its dissemination to the deeper tissues by way of the lymphatics. When the bone surface is involved, the osteoblasts are killed and bone destruction is carried out. When the cementum surface is contacted, over small or large areas, the cementoblasts are destroyed. With diffusion, or liberation, of the necrotizing agent into fiber bundles, these structures are disintegrated. Hemorrhages are produced through the action on the walls of blood vessels of the necrotizing substance which is liberated into the perivascular tissue. The attacks are probably of short duration.

According to our working hypothesis, the necrotizing agent may contain proteolytic enzymes. Wells (1920), in his studies on the pathogenesis of fat necrosis where extracts of fresh pancreas were injected into animals, found that the first change was a necrosis of surface endothelium. Rich and Duff (1936), in their investigations on the pathogenesis of acute hemorrhage pancreatitis, studied the action of the enzyme

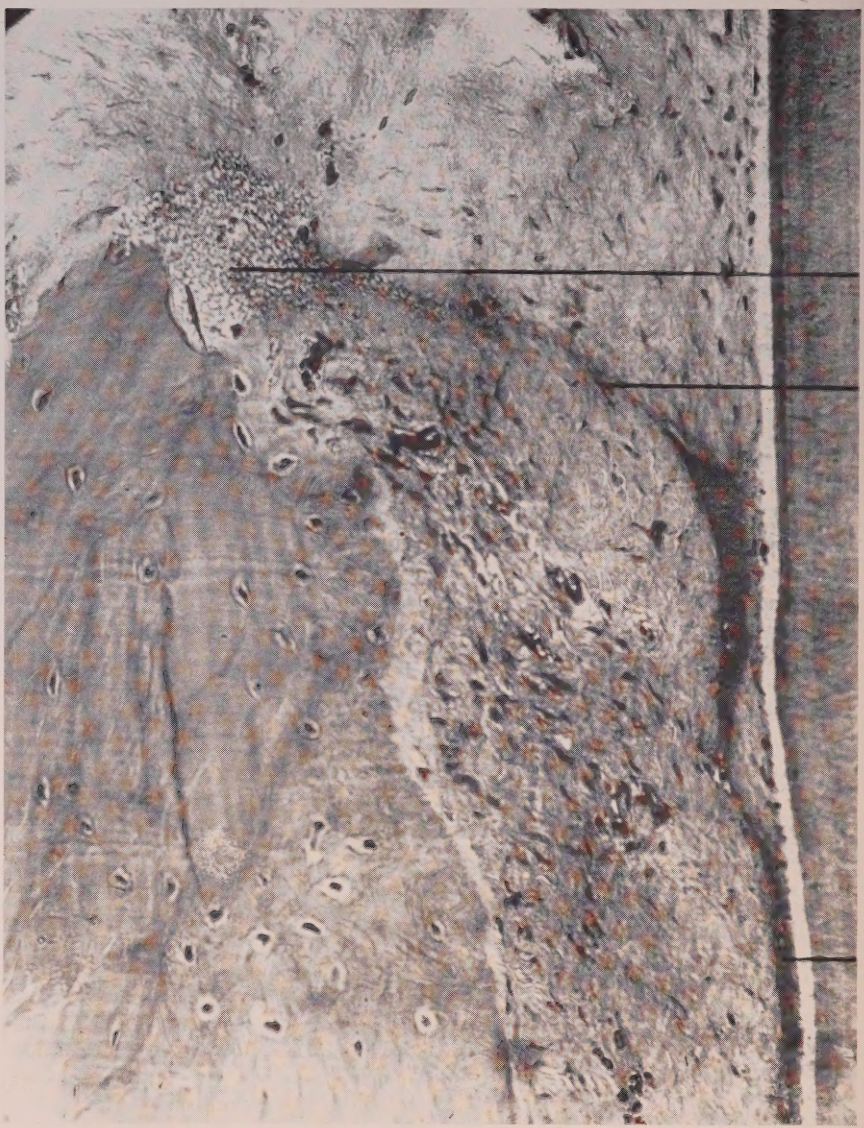

Fig 7 This illustration shows destruction of alveolar crest with marked vacuolation of the organic matrix. Note that a necrotic tract extends from this site across the periodontal membrane to and along the cementum surface. (Biopsy material.) a. Vacuolated matrix of alveolar crest; b. necrotic tract crossing periodontal membrane; c. tract extending along cementoid layer.

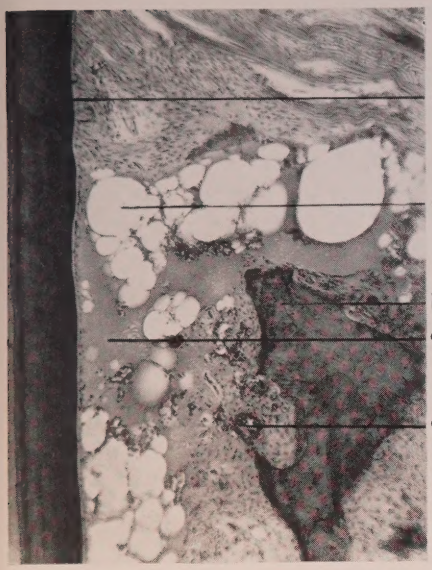

Fig. 8. Large destructive lesion involving cemental gingiva and periodontal membrane. (Autopsy material.) a. Cementum surface; b. alveolar crest; c. large alveolate space; d. coagulum showing mild vacuolation; e. blood vessel minus endothelium and almost filled with red blood cells.

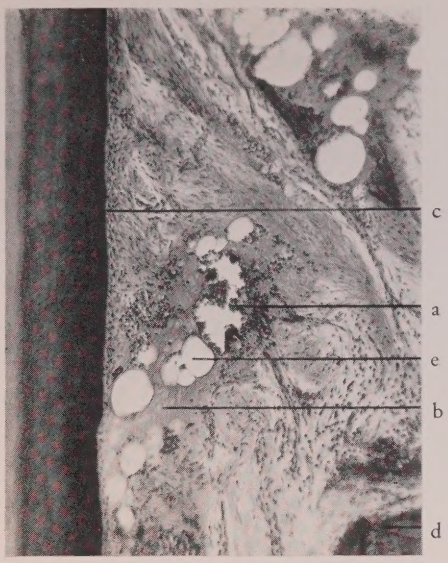

Fig. 9. Large hemorrhagic lesion in the soft tissue above the present alveolar crest. (Autopsy material.) a. Zone of hemorrhage; b. coagulum; c. cementum surface; d. alveolar crest; e. vacuole.

trypsin on blood vessels. They conducted experiments on dogs where solutions of trypsin were injected subcutaneously, and demonstrated that this enzyme has a powerful necrotizing action on the walls of blood vessels.

Menkin (1943, 1946) has described a toxic material liberated by injured cells into exudates, which he has termed "necrosin". This material contains proteolytic enzymes, and it has far-reaching repercussions on visceral organs when introduced into the circulation. It remains to be seen if there is any relationship between our necrotizing agent and Menkin's "necrosin".

As the necrotizing processes, described earlier, damage the attachment apparatus of the teeth, their relation to the clinical picture is marked chiefly by early loosening and displacement of the teeth, and deep pocket formation as a late symptom. In the terminal stages of the disease, the teeth are usually removed without difficulty. One thing seems certain, namely, that this concept of a mechanism involving extrinsic

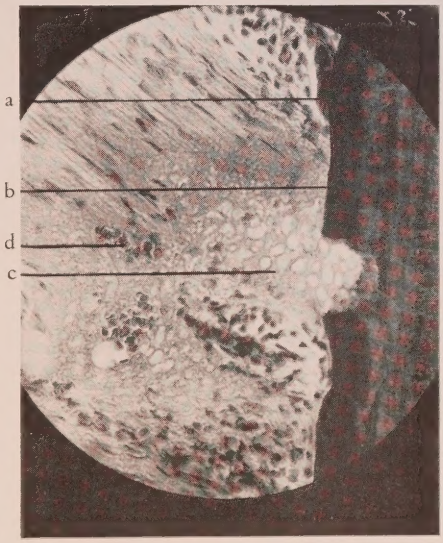

Fig. 10. Marked disorganization changes in fiber bundle just below base of epithelial attachment. (Autopsy material.) a. Epithelial attachment; b. cementum surface devoid of cementoblasts; c. zone of hyaline-like change and vacuolation; d. small capillary minus endothelium lying in disintegrated fibers.

causes has opened up new pathways in the field of periodontal research.

Time will not permit a discussion of some of the important problems now confronting the research worker. These include studies on the source of the necrotizing agent (Box, 1947); the protective role of inflammation; the repair of the lesions, including the status of pericementitis fibrosa (Box, 1924); and the possible role of anti-enzymatic substances of blood serum and tissue fluids in affecting the action of the incoming enzymes.

CONCLUSIONS

It is evident that these findings furnish little support of the viewpoint that toxic agents disseminated by way of the blood stream in various systemic conditions are responsible for the damage to the attachment apparatus of the teeth observed in one basic and especially destructive type of periodontal disease.

The immediate mechanism, which to date has been shrouded in obscurity, apparently involves extrinsic rather than intrinsic factors, but this is not to say that systemic conditions, operating as assisting or preventing agents, do not play an important part in the predisposing etiology.

I am under special obligation to Dr. Valy Menkin, Temple University Medical School, Philadelphia, and Dr. M. C. Dinberg, Pathologist, Department of Health, Province of Ontario. Their advice was invaluable, particularly in regard to interpretation of microscopic material. For their many suggestions, interest and courtesy, I wish to express my sincere appreciation.

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APPENDIX "H"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: An anatomical, histological and physiological study of the role of the condyle in mastication.

Project No. DR 11 (Report No.3)

Review of Past Studies and Discussion of Present Ones

As stated in Report No.2, there is no evidence that great macroscopic changes take place in the structures of the skull when teeth are removed from one side. The cases where deformed cranial formations are in evidence where teeth have been extracted may be due to other causes. There is a possibility, however, that alterations may take place in the condyle due to the altered chewing motions and habits when teeth have been extracted.

Preliminary experiments (Report No.1) were performed on growing rats. This, we found, is not correct for purposes of evaluation. It would be better if mature rats were used. Then changes would be shown after growth is completed. These changes should be seen microscopically. Areas of new growth and of resorption should be discernible.

It is doubtful whether Alizarine Red S. will be of much value in these studies. The condyle of a rat is rather small and small areas of new growth due to altered function might not be easily seen.

The Alizarine Red S. was added to the food of the rats rather than injected as previously intended. It was believed that the maintenance of the dye in the body would be more constant by this method than by injections at intervals. The effects of the dye will soon be disclosed.

The past several months have been marked by unavoidable delays in the work of this project. In addition to the few rats which we had on hand we had to obtain about ten more. We began dyeing operation on the latter at about maturity (120 days). The only rats we were able to obtain for these experiments were born Sept. 1, 1947. We had to wait until after December 10th to begin work on them. This work is still in progress at this time. Over 1,000 sections of the condyle are contemplated.

Dissections have already been done on a cadaver isolating the lateral and medial pterygoid muscles. We are pausing at

this stage so that we can correlate these studies with the findings made on the gnathoscope and gnathograph. These instruments should have arrived in October, 1947, but will not be ready until March, 1948. They are necessary for our studies of the Bennett movement. We shall begin these studies as soon as the instruments are delivered.

The axis of the opening movement will also be studied during 1948 from a different approach. This will begin just as soon as a cephalometer is installed at the University of Toronto. It will be recalled that some experiments were done which proved that the axis hinge of opening movement is located in the condyle rather than in the vicinity of the mandibular foramen, the latter being the opinion of the majority of anatomists. It will probably mean that the proposed experiments will disclose whether this axis is fixed and/or constant.

Proposed Work for the Year

1. Condyles of Rats

Studies to determine whether alterations of the structures of the condyles occur when teeth are extracted will be made chiefly by means of microscopical analyses of sections. In a few cases attempts will be made to study the effects of unilateral extractions macroscopically, using Alizarine Red S. About a thousand sections will be thus analysed.

2. Gnathoscopic and Gnathographic Studies

Registrations will be made of condyllar movement in humans. These registrations are pantographic in character. They will be broken down to analyse muscular movements. The cadaver will be useful in these studies. If possible we shall attempt to produce portions of these tracings by means of electrical stimuli on portions of muscle on a live patient. Thus a dissection may be effected on living material and the role of muscles or portions of muscles may be studied. Information gained from reliable sources indicate that these proposed experiments are practical.

3. Cephalometric Studies

The hinge axis of opening movement can be accurately studied by means of a cephalometer. This will have to be done on a great many cases. Studies will be commenced as soon as the apparatus arrives.

Conclusions

The experimental work program is expanding satisfactorily. The delays caused by late deliveries of pieces of apparatus have been rather disconcerting, but have given us the opportunity of studying the problems, scanning the literature, and planning the future work more accurately. We believe that the ultimate results will prove that we have gained considerable new knowledge of this subject. 1948 should be marked by much progress.

Charles H. Moses
Research Assistant.

Faculty of Dentistry,
University of Toronto

January,
1 9 4 8.

APPENDIX "I"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry.

Grantee: Drs. O. J. Walker and H. R. MacLean

Project No.: DR 9 Amount of Grant: $1,000.

SUMMARY OF WORK

Test runs are being made at present to determine the corrosion resistance of dental alloys sold under the trade names of Denchrome, Durallium, Vitallium and Ticonium. These alloys contain chromium, vanadium, cobalt and nickel. The chromium and vanadium content has been determined and analyses for cobalt and nickel are almost completed. The biggest problem encountered has been the difficulty of getting the various alloys into solution for analysis. It is proposed also to test various plastics in a similar manner.

The method of testing used is to extend 1 cm.square test pieces of the alloy into saturated solutions of Polident or Stera-kleen. It is proposed to test the alloys and plastics in solutions of varying concentrations of Hygeol. The flasks containing the solutions are kept in a thermostated bath and shaken manually from time to time. Corrosion is determined by loss in weight.

Experiments have been made for times of exposure up to one month in saturated solutions of Polident and Stera-kleen. Results for Durallium show average corrosion of only 0.096% in Stera-kleen and 0.085% in Polident. Tests runs are in progress for long-term exposures of the other alloys.

Date: February 11, 1948.

APPENDIX "I"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry.

Grantees: O. J. Walker and H. R. MacLean

Project No. DR 9 Amount of Grant: $1,000.

CORROSION OF DENTAL MATERIALS

It is proposed to study the corroding effects of certain commercial preparations on some of the common dental alloys. For this purpose, samples have been obtained of Denchrome, Durallium, Vitallium, and Ticonium. It is hoped to test samples of various plastics in subsequent experiments. The commercial preparations to be used were Stera-Kleen, Polident, and Hygeol. In response to our letters, the Stafford-Miller Company (of Canada) Limited sent us five pounds of Polident; McGillivray Brother Limited sent us five pounds of Stera-Kleen; but the Henry K. Walpole Company wrote that Hygeol could not be obtained in bulk.

First step is the analysis of samples especially for content of Chromium, Vanadium, Cobalt, and Nickel, since these metals when alloyed with steel seem to produce most resistance to corrosion.

The method used for the determination of Chromium is a modification of that given in Willard and Diehl, - "Advanced Quantitative Analysis". The Chromium and Vanadium in solution are oxidized to chromic acid and vanadic acid, and after removal of excess oxidizing agent, these two acids are titrated with standard ferrous sulfate. Knowing the vanadium content as a result of separate determination, the chromium is obtained by difference. The sample is dissolved in 50% phosphoric acid and then 1.5 ml. concentrated sulfuric acid are added for each gram of sample plus 3 ml. excess acid. Concentrated nitric acid is used for the preliminary oxidation, and the oxidation of chromium and vanadium to chromic acid and vanadic acid is effected using ammonium persulfate in a dilute sulfuric acid solution containing silver as a catalyst. Excess persulfate is destroyed by boiling and dilute hydrochloric acid is added to destroy any permanganic acid formed by the oxidation of manganese, and also to precipitate the excess silver ion. This silver chloride precipitate acts as a catalyst in the reduction of permanganic acid.

Equations involved are:

$$Cr_2(SO_4)_3 + 3(NH_4)_2S_2O_8 + 8H_2O \rightarrow 2H_2CrO_4 + 3(NH_4)_2SO_4 + 6H_2SO_4$$

$$2VOSO_4 + (NH_4)_2S_2O_8 + 4H_2O \rightarrow 2HVO_3 + (NH_4)_2SO_4 + 3H_2SO_4$$

$$2HMnO_4 + 14HCl \rightarrow 2MnCl_2 + 5Cl_2 + 8H_2O$$

After cooling, sodium acetate is added to react with the excess of concentrated sulfuric acid used in dissolving the steel, since the colour change of the indicator from purple to green at the endpoint is much sharper in a buffered solution than in one of high hydrogen ion concentration. 1% diphenyl-benzidene is used as indicator and after five minutes standing, the chromic acid and vanadic acid are titrated with standard ferrous sulfate.

Reactions are:

$$2HVO_3 + 2FeSO_4 + 3H_2SO_4 \rightarrow 2VOSO_4 + Fe_2(SO_4)_3 + 4H_2O$$

$$2H_2CrO_4 + 6FeSO_4 + 6H_2SO_4 \rightarrow Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 8H_2O$$

The total of chromium and vanadium is calculated as percentage chromium according to the equation:

$$\%(Cr + V) \text{ as } Cr = \frac{Cr \times ml\ FeSO_4 \times normality\ FeSO_4 \times 100}{3 \times 1000 \times Weight\ of\ sample}$$

The same solution is used for the determination of vanadium. Tenth normal potassium permanganate is used to oxidize ferrous sulfate and vanadyl sulfate.

$$10VOSO_4 + 2KMnO_4 + 12\ H_2O \rightarrow 10HVO_3 + 2MnSO_4 + K_2SO_4 + 7H_2O$$

$$10FeSO_4 + 2KMnO_4 + 8\ H_2SO_4 \rightarrow 5Fe_2(SO_4)_3 + 2MnSO_4 + K_2SO_4 + 8H_2O$$

Excess of potassium permanganate is destroyed by the addition of sodium nitrite and any excess of nitrous acid is removed by the addition of urea. Excess of urea does not interfere with the titration of the vanadic acid by ferrous sulfate. The indicator used is oxidized diphenyl aminesulfonic acid.

$$2HVO_3 + 2FeSO_4 + 3H_2SO_4 \rightarrow 2VOSO_4 + Fe_2(SO_4)_3 + 4H_2O$$

$$\%V = \frac{V \times ml\ Fe\ SO_4 \times normality\ FeSO_4 \times 100}{1000 \times weight\ of\ sample}$$

$$\%V \times \frac{Cr}{3V} = \%\ Cr \text{ equivalent to } V$$

Thus: $\%\ Cr = \%(Cr + V) \text{ as } Cr - \%\ Cr \text{ equivalent to } V$

The method used for the determination of cobalt is found in Volume 1, Fourth Edition, of Scott "Standard Methods of Chemical Analysis" . The sample is dissolved in concentrated hydrochloric acid and the iron and tungsten etc. are oxidized by concentrated nitric acid. Excess nitric acid is removed by boiling. A fresh solution of zinc oxide is added in slight excess, and the precipitate filtered off. The cobalt is then precipitated from the boiling hydrochloric acid solution by freshly prepared nitroso-B-naphthol in 50% acetic acid. The precipitate is heated gently in a porcelain crucible until the carbon is all oxidized and is then heated strongly until ignition is completed. The cobalt is weighed as the oxide, Co_3O_4.

$$\%Co = \text{Weight of } Co_3O_4 \times 0.734 \text{ (for a 1 gram sample.)}$$

The method used for the determination of nickel is the standard method to be found in any text on quantitative analysis - the precipitation of nickel by a 1% ethanol solution of dimethylglyoxime. The sample is dissolved in aqua regia (HNO_3: $3HCl$: $4H_2O$). Nickel dimethylglyoxime forms in ammoniacal, neutral or acetate-buffered solution, but is soluble in mineral acids, cyanides, and organic solvents. For our purposes, a neutral to slightly ammoniacal solution is used. The solution is treated with a reducing agent to reduce the iron to the ferrous state. Tartaric acid is added to prevent the precipitation of the dimethylglyoximes of iron, aluminum, and chromium, and this does not interfere with the precipitation of the nickel. The cobalt dimethylglyoxime forms but is soluble so sufficient dimethylglyoxime solution must be added to combine with all the cobalt present. Not more than 5% excess of the alcohol solution may be added due to the insolubility of the dimethylglyoxime in water. Precipitation is made in a warm solution and after cooling the precipitate is filtered off through asbestos and dried in an oven at 110°C.

$$\%Ni = \frac{\text{weight of precipitate}}{\text{weight of sample}} \times 0.2032 \times 100$$

Owing to the difficulty of solution of the samples and a failure to obtain check results until a large number of determinations were completed, the analyses are not yet completed. Some of the results available at present are given here:

Denchrome

%(Cr + V) as Cr	%V	%Cr
9.26	0.10	9.23
9.32	0.10	9.28
9.30	0.16	9.25
9.35	0.16	9.30
9.34	0.11	9.30
9.34	0.11	9.30
9.34	0.10	9.31
Averages 9.34	0.13	9.28

Durallium

%(Cr + V) as Cr	%V	%Cr
13.58	0.27	13.49
13.59	0.26	13.50
13.48	0.25	13.39
13.50	0.24	13.42
Averages 13.45	0.26	13.45

Vitallium

%(Cr + V) as Cr	%V	%Cr
14.29	0.20	14.32
14.43	0.20	14.36
14.29	0.18	14.23
14.55	0.15	14.50
14.44	0.15	14.39
14.48	0.15	14.43
Averages 14.41	0.17	14.36

Ticonium

%(Cr + V) as Cr	%V	%Cr
9.79	0.23	9.71
9.98	0.22	9.90
9.07	0.24	8.99
9.63	0.28	9.53
9.09	0.21	9.02
9.10	0.23	9.02
Averages 9.45	0.27	9.53

The nickel and cobalt analyses are still in progress. However, preliminary results show the percentage of nickel in Denchrome to be of the order of 5% and in Durallium to be lower - probably about 2%. The percentage of cobalt in Denchrome is of the order of 0.1 - 0.2%.

Next step is the actual corrosion tests. Considerable reading was done on the various types of corrosion tests which have been utilized for various tasks. It was decided that for our purposes it would be best to use the continuous total immersion type of test, preferably with some sort of motion of the sample within the corrosion medium. Since close temperature control seemed advisable, one attempted to get some sort of wrist action shaker which could be used in a thermostatically controlled water bath. Such a shaker is apparently not available and the possibility of economically revamping any existing shaker was ruled out by Canadian Laboratory Supplies Limited after some correspondence with them.

It was decided to measure corrosion by the loss in weight method since this seems to be the most accurate method with the equipment at our disposal.

The size of the test piece chosen was one square centimeter with a one sixteenth inch diameter hole in the center so that they may be suspended into the test solution. The samples are suspended by crochet cotton which passes through the rubber stoppers on the flasks and through the hole in the test piece where it is secured by a small knot.

The method used for cleaning test pieces is a preliminary dip for ten minutes in concentrated hydrochloric acid followed by two treatments of one half hour each in distilled water. This is followed by a half-hour bath in ethanol and fifteen minutes soaking in ether. Finally the test piece is left in a desiccator for one hour before weighing.

Saturated solutions of Stera-Kleen and Polident are used as the corroding medium. 250 ml. of solution are used for each test piece, and only one test piece is tested in each vessel. The vessels are 300 ml. Erlenmeyer flasks which are suspended into a thermostatically controlled water bath. The method of shaking to date leaves much to be desired--it consists of manual shaking of the flasks each morning during the tests.

Tests run at a controlled temperature of 50°C for 48 hour periods have shown no corrosion on any samples used. 50°C was chosen since this temperature will give a considerably accelerated corrosion rate compared with the rate of corrosion during actual use of the alloys.

Lately we have obtained a larger bath which has enabled us to run tests on more samples at once and thus to run the tests for longer periods of time. Results available at present for 1 square cm. test pieces in 250ml. saturated solution are as follows:

DURALLIUM

	Weight of sample (grams)	Loss in Weight over Period of 4 weeks at 50°C. (grams)	% Corrosion
In Polident	0.4582	0.0004	0.087
	0.4069	0.0004	0.098
	0.6005	0.0004	0.066
	0.6801	0.0006	0.088
	0.6822	0.0004	0.059
In Stera-Kleen	0.5736	0.0006	0.105
	0.5865	0.0006	0.102
	0.3872	0.0003	0.077

Long exposure tests are almost completed on samples of denchrome, but owing to the length of time involved for each test results come very slowly.

Now that the apparatus is properly set up and check results are being obtained, it is hoped that progress will be faster. Very small corrosion is noticed with samples of Polident and Stera-Kleen, but more positive results are expected when work with Hygeol is completed. It is hoped, time permitting, to test several other commercial preparations in a similar manner.

Dorothy E. Coggles
Research Assistant.

APPENDIX "J"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: An investigation of the effects of solutions used in operative dentistry on the vital pulps of teeth.

Grantee: Dr. R.F. Shaner

Project No. DR 17 Amount of Grant: $1,000

SUMMARY OF WORK

1. The literature from 1936 to the present was read and summarized.

2. Very courteous and useful communications were received from Manley, Orban, Grossman, Schour and Shroff.

3. Using normal and pathological human teeth trial was made of various techniques of embedding and staining.

4. Experiments on animals were begun using rats and cats. Dogs are to be used. These tests confirmed the findings of Manley, Shroff, Gurley and Van Huysen, i.e., zinc oxide and eugenol base exhibits peculiar anodyne properties and shows no signs of pulpal irritation. This conclusion was based on the examination of several histological slides.

5. A possible relation between peripheral leak of some filling materials and the investigation in hand arose from repetition of an experiment by Grossman using glass tubes. Several cements exhibited shrinkage. Where peripheral seal was defective pulpitis was evident in the slides.

6. Dr. D.B. Scott of the Department of Physics offered to secure radioactive phosphorous to trace the penetration in the tooth of the orthophosphoric acid used in dental cements. Radioactive silver will also be used to trace silver nitrate placed within a cavity.

February,
1 9 4 8 .

APPENDIX "K"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Improvement of sub-gingival curettage and surgical techniques used in the treatment of "pyorrhea alveolaris".

Grantee: Dr. Jules Thébaud

Project No. DR 20

The investigation was begun on November 20, 1947, and to date, approximately forty-six hours were dedicated to the project.

Objective

The proposed research will deal first with some technical improvement of the subgingival curettage, and later, if possible, an attempt will be made to combine this improvement with some modifications to be added in Gingivectomy and semi-flap curettage.

The change contemplated here is based on the improvement of the armamentarium commonly used in the performance of the two well-known steps:- a) the curettement of the cemental wall, or hard side of the periodontal pocket and b) the curettment of the soft periodontal wall; also, c) the development of a third step for the curettement of the so-called base or bottom of the pathological sulci.

1. CURETTAGE OF THE CEMENTAL WALL

In accordance with the principles formulated by Box about the curettement of the cemental wall of the pocket (Treatment of Periodontal Pocket, p.44-66), and the technique described by Miller (Periodontia, chapter 8), we scaled a certain number of teeth on which some tartar deposits were found on the gingival third, in order to study: a) The effect of the use of each instrument on the cemental substance. b) The combined effect of the curette, the hoe and the file. c) The effect obtained by the too strenuous use of each of these instruments, and also that obtained with moderate use. d) The susceptibility of the cement to be removed at the gingival third, and the possible exposure and gouging of the dentine.

In our aim to deal exclusively with the removal of fine subgingival tartar on the cemental surface, we have eliminated

the scalers used in the supragingival scaling, such as the chisel, the sickle, and other prophylactic instruments. We substituted the McCall type of curette, Nos. 13 and 14, anteriors, and the posteriors Nos. 17 and 18, and six types of hoes.

The experiments were carried out on three groups of teeth:-

Group 1 Teeth extracted and selected at random, on which a certain amount of calcarous deposits were remarked on the gingival third, and on which the periodontal membrane attachment could be detected, exposed and measured from the enamocemental junction, after a few hours in a formol bath, (see Table 1 and Figs. 1 and 2).

Group 2 Teeth involved with periodontal pathosis which were examined and treated in the mouth of patients whose case history was recorded, including individual radiogram and pocket measurement for each tooth (Fig.3). Also evidence of mobility and the presence of subgingival calcific deposits were noted and listed (Table 3).

Experiments

Scaling was performed on both groups with the proper hoes and curettes, using only routine planing on the extracted teeth, Group 1, and both spot curettage and routine planing on the teeth Group 2, "in situ", before they were extracted.

The finishing phase was added on a few teeth with proper files, and also with new materials such as flattened carborundum points, sanded steel, (Moyer's abrasive) and portion of carborundum disk as listed in Tables 2 and 4.

In order to make our observation clearer nine teeth, selected in Group 1 were notched at the apical third, on the mesial side, for identification of that side, and curettage or scaling was performed separately with different instruments on the mesial and distal surfaces of the roots as shown in Tables 5 and 6.

General Considerations

We consider scaling with the curette alone, or the curette combined with the hoe as a classical and routine procedure, and finishing with the file and other materials as complementary procedure for polishing the cemental surface, in removing or checking bosselations, irregularities, and

discrete calcarous remnants, creating thus a suitable foundation for the organization of the blood clot and a possible reattachment of the periodontal membrane.

We are trying to find the real value of the process of finishing and also to bring more accuracy to the execution of that phase of the curettage. The experiments on extracted teeth were made under magnifying glass, which made it possible for us to obtain more details during our macroscopic study.

Curette

When the curette is used alone, a glassy and even surface is obtained.

Hoe

Removal of fine calcarous particules is incomplete and gouging or grooving of the cement can readily be seen when this instrument is too freely used. The necessity of using the curette afterwards is then more evident.

File

The use of this instrument is inadequate for the removal of large masses of tartar, but excellent in checking and removing small remnants; and it is astounding how effectively the difficulty pointed out by Bodecker is overcome in the course of this operation. The amount of cement shaved by this instrument is, however, considerable.

Carborundum and Sanded Steel

But there is a less-marked loss of cemental substance in the moderate use of the so-called abrasives. A flattened carborundum disk, and a portion of sanded steel disk were the materials recently tried. The glossy cemental surface obtained by the use of the curette becomes a smooth, dull surface when the finishing process is done with the file; and even duller with the use of the new materials.

Stain

The root surface absorbs methylene blue more deeply after finishing with the new materials, and blood gives a thicker, firmer clot when placed on a root thus treated.

Microscopic Studies

To date only six specimens have been thoroughly decalcified and mounted (Figs.1,2,3).

Further observations will be recorded later.

2. CURETTEMENT OF THE SOFT TISSUE (PERIODONTAL WALL)

Before looking for a more radical method of eliminating the layers of epithelial cells at the inner wall of the soft side of the pocket, and removing more efficiently the underlying granulation tissue, we shall endeavor to find a means of more thoroughly curetting the base of the pocket which is ulcerated or biologically disorganized.

3. CURETTEMENT OF THE BASE OF THE POCKET

In view of curetting the soft tissue at the base of the pocket whence the epithelial cells emigrate to the apex and where the vitality of the cement diminishes, we have constantly in mind the investigation made by Bodecker (The Journal of the American Dental Association, p.703. 1943) in which he discovered the disproportion between the size of the curettes generally used on the surface of the roots in scaling, and the size of the opening of the pockets. This disproportion is still greater when one considers the necessity of curetting the base of the pocket by using these same curettes, since this part of the pocket is largely formed by the periodontal membrane in a pathological condition.

With this idea in mind, we have tried a type of curette whose thickness is about the same as that of the periodontal membrane.

This instrument possesses a certain flexibility which permits the pressure applied during curetting to be deadened, and allows the disorganized cells to be eliminated without breaking the fibres of attachment, actually combing them by its multiple tiny spikes (Figs. 4,5,6,7,8).

The ordinary curette, on account of its rigidity and its disproportionate size in comparison to the delicate membrane (Figs.10 - 18) is less efficient. We have tried to give several shapes to these curettes by submitting the broaches to the action of heat during soldering, but the experiment was not successful, as they became too brittle.(Fig.19)

The loop shape of this type of curette meets our requirements, and will not create any problem for the manufacturer. In order to check the accuracy of this instrument we experimented with it at the base of the sulcus located between the nail and the flesh of the finger-tip. These tissues, by their anatomical arrangement resemble the periodontal sulcus or pocket in that they have a soft and a hard wall. (Figs.20,21,22)

This experiment was successful in easily removing any fine particles of débris purposely placed under the nail, and

the cleaning process was still more efficient when McCall's solution was used.

We are now looking forward to ascertaining in just what thickness this curette is most likely to be efficient. We are also trying to find a more suitable shape for it, one which will enable it to be equally efficacious in the treatment of either an interproximal, a buccal or a lingual pocket, - of anterior or posterior teeth, on the right or left side (Figs. 23 - 27).

Further investigation will be carried on on autopsy and biopsy materials.

January,
1 9 4 8.

TABLE I

EXTRACTED TEETH SCALED AT THE GINGIVAL THIRD (SELECTED AT RANDOM).

Serial Number	Tooth	Deposit	Distance from Enamo-Cemental Junction to Attachment of Periodontal Membrane: Mesial	Distal	Date Scaling or Finishing.	Date Decalcifying Process.
x 1	L.L. bicuspid	++	3-1/2 m/m	3 m/m	Dec. 47	Dec. 47
x 2	R.L. cuspid	+	3 m/m	3-1/2 m/m	" 47	" 47
x 3	R. upper cuspid	++	4-1/2 m/m	3 m/m	" 47	" 47
x 4	L. upper cuspid	+	3 m/m	3-1/2 m/m	" 47	" 47
x 5	L.2 upper molar	++	3 m/m	3-1/2 m/m	" 47	" 47
x 6	R.upper molar	++	3-1/2 m/m	2 m/m	" 47	" 47
x 7	L. upper molar	++	2-1/2 m/m	2-1/2 m/m	" 47	" 47
x 8	R. upper cuspid	++	6 m/m	4 m/m	" 47	" 47
x 9	L.L. bicuspid	+++	3 m/m	4 m/m	Jan. 48	Jan. 48
x 10	R. upper bi-cuspid	+++	2-1/2 m/m	3-1/2 m/m	" 48	" 48
x 11	R. upper bi-cuspid	++++	3 m/m	5 m/m	" 48	" 48
x 12	R. upper molar	++	4 m/m	6 m/m	" 48	" 48
x 13	R. upper molar	++	2-1/2 m/m	4 m/m	" 48	" 48
x 14	L. lower cuspid	++	4 m/m	6 m/m	" 48	" 48
x 15	R. upper cuspid	++	2-1/2 m/m	3-1/2 m/m	" 48	" 48

TABLE II

INSTRUMENTS USED IN SCALING THE GINGIVAL THIRD OF 15 EXTRACTED

Serial Number	Tooth	Date Scaling or Finishing.	Instrumentation	Sides Scaled	
x 1	L.L. bicuspid	Dec. 47	Carborundum (Flat point)	Mesial	Distal
x 2	R.L. cuspid	" 47	Curette & carborundum (flat point)	"	"
x 3	R. upper cuspid	" 47	Cemental file	"	"
x 4	L. upper cuspid	" 47	Corborundum (portion of disk)	"	"
x 5	L. upper molar	" 47	Sanded steel (Moyer's)	"	"
x 6	R. upper molar	" 47	Hoe & curette & carborundum (F.P.)	"	"
x 7	L. upper molar	" 47	File on mesial - carborundum on distal	"	"
x 8	R. upper cuspid	Jan. 48	Curette (alone)	"	"
x 9	L.L. bicuspid	" 48	Hoe & curette	"	"
x 10	R. upper bicuspid	" 48	Curette & file	"	"
x 11	R. upper cuspid	" 48	Hoe & curette & file	"	"
x 12	R. upper molar	" 48	Hoe	Buccal.	Lingual.
x 13	R. upper molar	" 48	Hoe & file	"	"
x 14	L. lower cuspid	" 48	Hoe & curette & sanded steel	Mesial	Distal
x 15	R. upper cuspid	" 48	Curette & sanded steel	"	"

TABLE III

SUBGINGIVAL SCALING MADE "IN SITU" ON TEETH, WITH RADIOGRAM AND CASE HISTORY (REPEATING THE SAME EXPERIMENT MADE FOR GROUP 1, TABLE 1 & 2)

Serial Number	Patients	Tooth	X-ray	Mobility	Depth of Pockets Mesial	Depth of Pockets Distal	Calcarous Ging. Supra	Deposits Ging. Infra	Date Extrac.
A	C	R.L. cuspid	+	2	2 m/m	3 m/m	+	++	Nov.47
B	D	L.L. bicus-pid	+	2	3 m/m	3 m/m	+	++	Nov.47
C	L	Upper R. molar	+	2	4 m/m	3 m/m	+	+	Nov.47
D	C	L.L. cuspid	+	1	2 m/m	2-1/2 m/m	+	+	Nov.47
E	K	R. upper molar	+	3	3 m/m	4 m/m	++	+	Dec.47
F	L	L.L. molar	+	3	4-1/2 m/m	4 m/m	+	+	Dec.47
G	C	L. lateral	+	1	2 m/m	2 m/m	++	+	Nov.47
H	A	R. upper molar	+	3	5 m/m	7 m/m	++	+++	Dec.47
I	L	L. upper molar		3	5 m/m	3 m/m	+	+++	Jan.48
J	X	L. upper cuspid	+	2	3-1/2 m/m	2 m/m	++	++	Jan.48

TABLE IV

INSTRUMENTS USED IN SUBGINGIVAL SCALING OF TEETH "IN SITU"
(With case history(

Serial Number	Tooth	Date Scaling or Finishing	Instrumentation	Side Scaled		Date Decalcifying Process
A	R.L. cuspid	Nov. 47	Curette	Mes.	Dis.	Dec. 47
B	L.L. bicuspid	Nov. 47	Curette & file	"	"	Dec. 47
C	Upper right molar	Nov. 47	Hoe & curette & file	"	"	Dec. 47
D	L.L. cuspid	Nov. 47	Curette & hoe	"	"	Dec. 47
E	R. upper molar	Dec. 47	Hoe	"	"	Dec. 47
F	L. lower molar	Dec. 47	Curette & carborundum	"	"	Dec. 47
G	L. lateral	Dec. 47	Hoe & file	"	"	Nov. 47
H	R. upper molar	Dec. 47	Curette & carborundum	At.	Mes.	Dec. 47
I	L. upper molar	Jan. 48	File	Mes.	Dis.	Jan. 48
J	L. upper cuspid	Jan. 48	Sanded steel	"	"	Jan. 48

TABLE V

INSTRUMENTS USED IN SCALING ON THE MESIAL AND DISTAL SIDES OF 5 TEETH

Serial Number	Tooth	Scaling of Mesial side: Instrumentation	Scaling Distal side: Instrumentation	Date Scaling	Date Decalcifying
D 1	L.L. cuspid	Curette	Hoe	Nov. 47	Dec. 47
D 2	R. upper molar	Curette	File	Nov. 47	Dec. 47
D 3	L.L. cuspid	Curette	Carborundum B.	Dec. 47	Dec. 47
D 4	L.L. bicuspid	Curette	Sanded Steel	Dec. 47	Dec. 47
D 5	L.R. bicuspid	Curette	Carborundum disk	Jan. 48	Jan. 48

TABLE VI

INSTRUMENTS USED IN FINISHING THE CEMENTAL SURFACE OF 4 TEETH

Serial Number	Tooth	Scaling of Mesial side: Instrumentation	Scaling of Distal side: Instrumentation	Date	
				Scaling	Decalcifying
D 6	L.L. cuspid	File	Carborundum (bur)	Dec. 47	Jan. 48
D 7	R.upper central	File	Sanded steel	Jan. 48	Jan. 48
D 8	R.L. cuspid	File	Carborundum (disk)	Jan. 48	Jan. 48
D 9	L.L. cuspid	Carborundum (bur)	Sanded steel	Jan. 48	Jan. 48

TABLE VI

INSTRUMENTS USED IN FINISHING THE CONCAVE SURFACE OF A TEETH

Fig. 1. Teeth, Group 1, during decalcifying process.

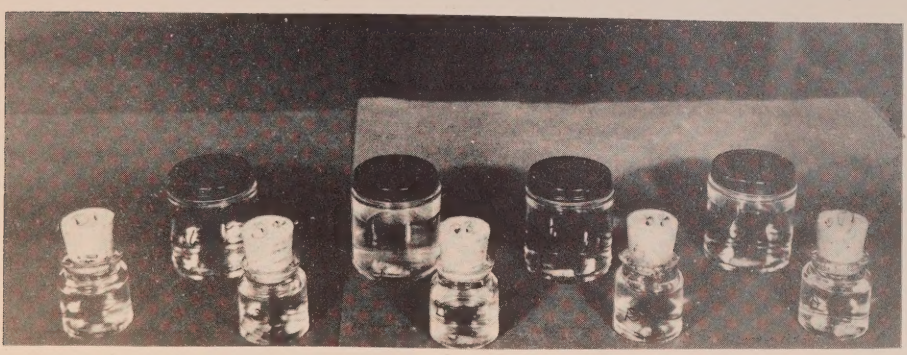


Fig. 2. Teeth scaled on the mesial and distal sides with different instruments (during decalcifying process).

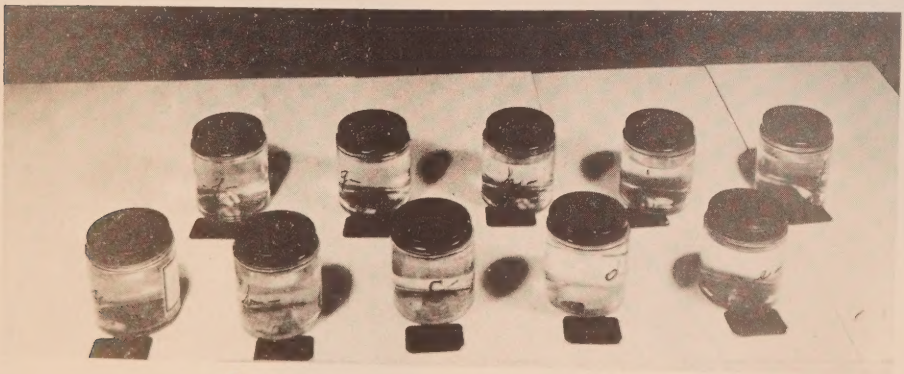


Fig. 3. Teeth, Group 2, during decalcifying process.

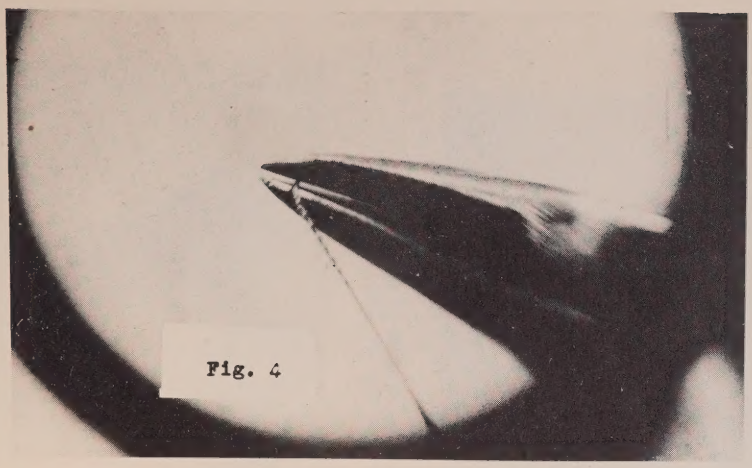


Fig. 4

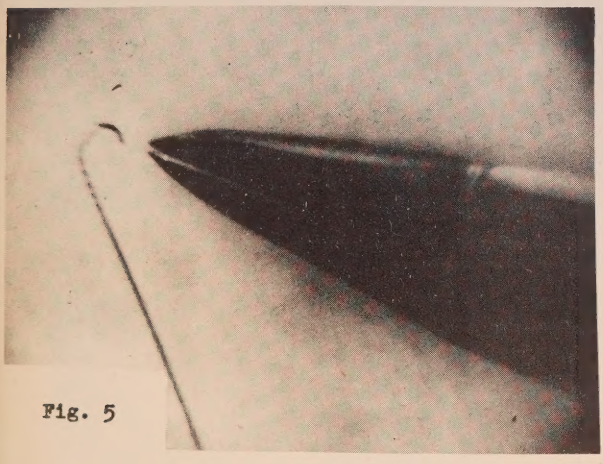


Fig. 5

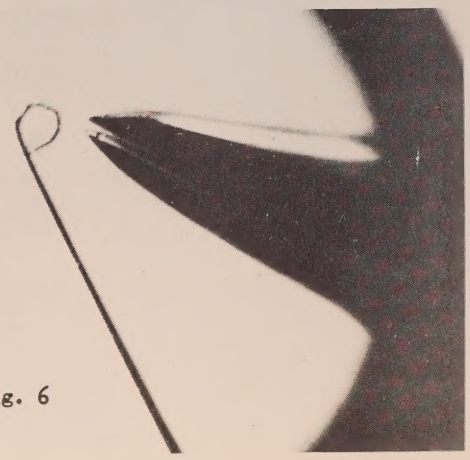


Fig. 6

Fig. 7

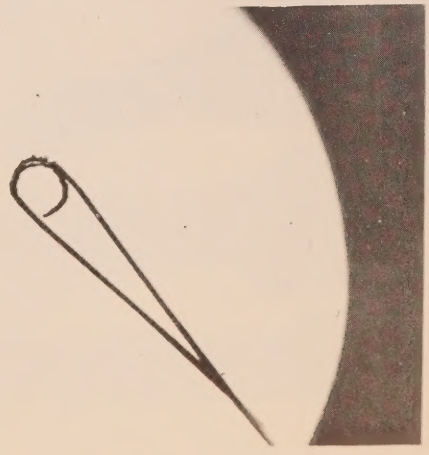


Fig. 8

Fig. 12. Introducing the Broach-curette at the base of the pocket.

Fig. 13. Broach-curette in position at the bottom of the pocket.

Fig. 10. Deep periodontal pocket on the distal of an upper-cuspid.

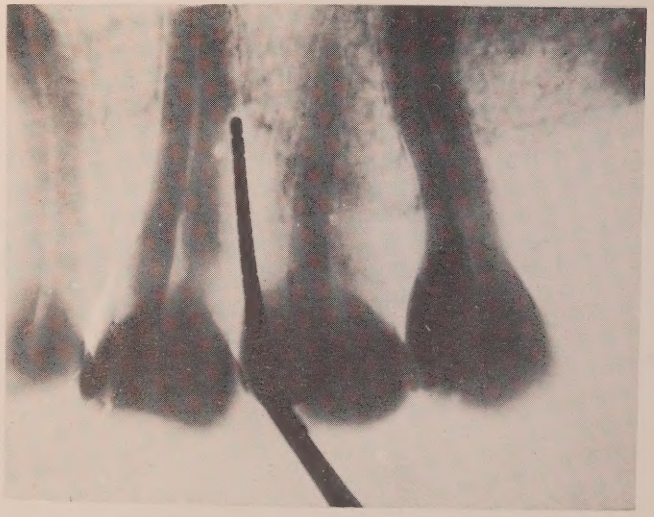


Fig. 11. Probing of the pocket.

Fig. 14. Compare size of curette with thickness of periodontal membrane.

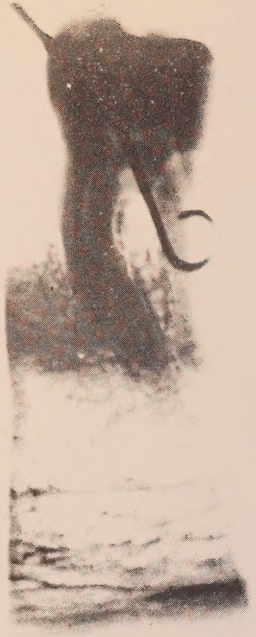


Fig. 15. Compare size of Broach-curette with McCall curette.

Fig. 16. Probing of a pocket (disto-buccal)

Fig. 17. McCall's curette in position.

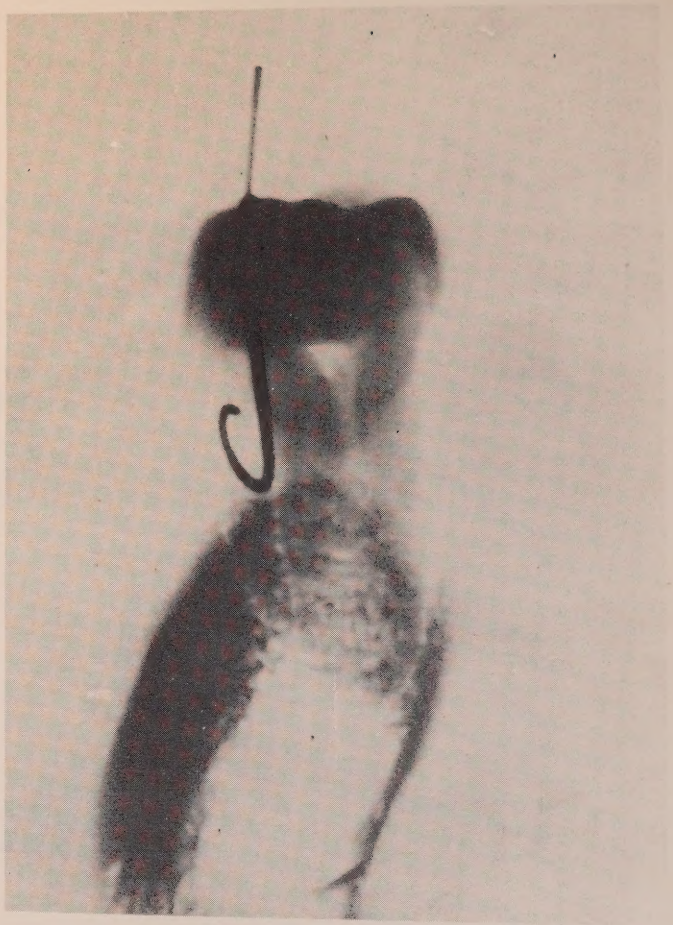


Fig. 18. Broach-curette in position at the bottom of the pocket.

Fig. 19.

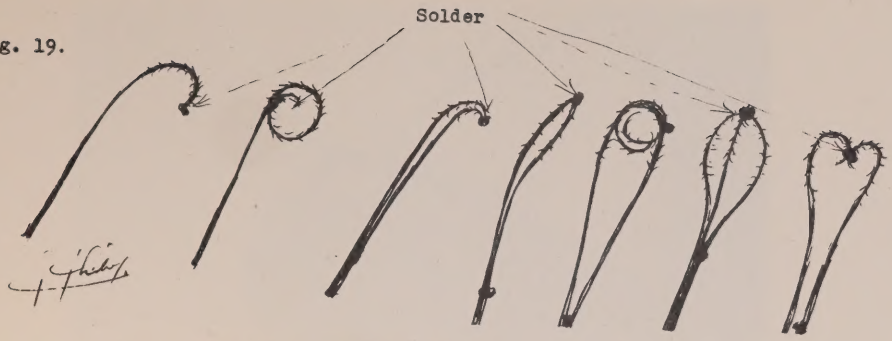


Fig. 20. McCall's curette in position at the sulcus of the nail (Note impossibility to reach the bottom).

Fig. 21. Broach-curette in position at the base of the sulcus of the nail.

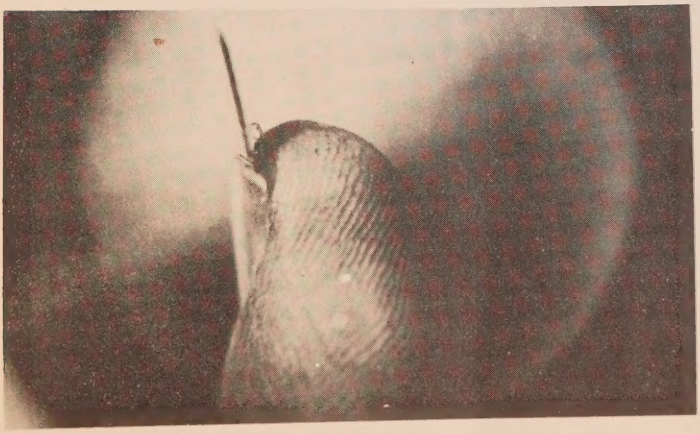
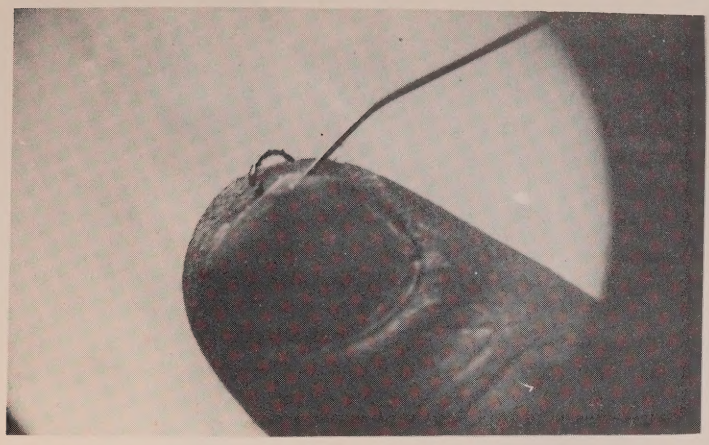


Fig. 22. Broach-curette in position at the base of the sulcus of the nail



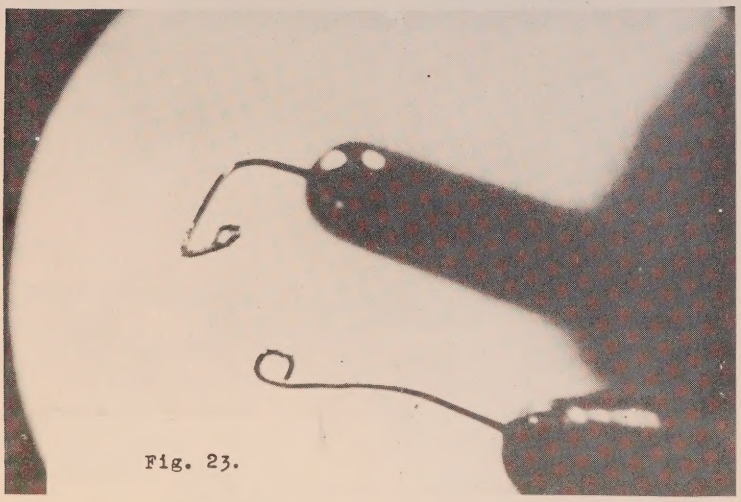


Fig. 23.

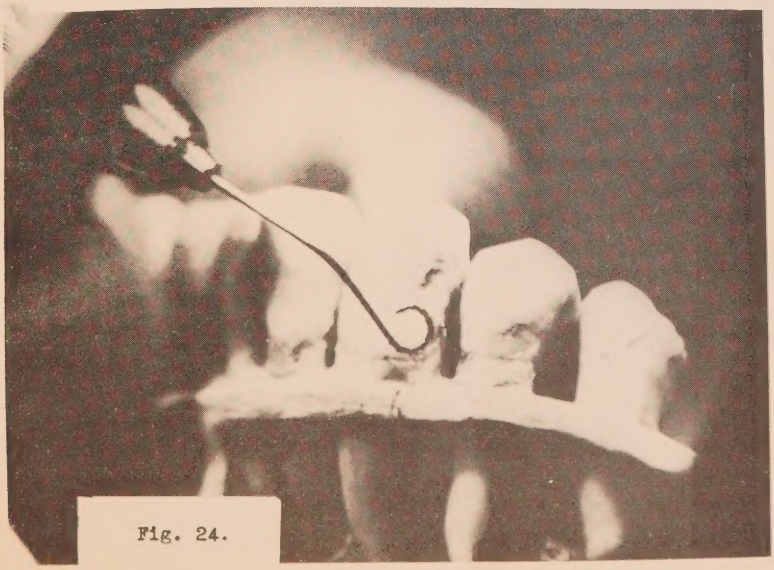


Fig. 24.

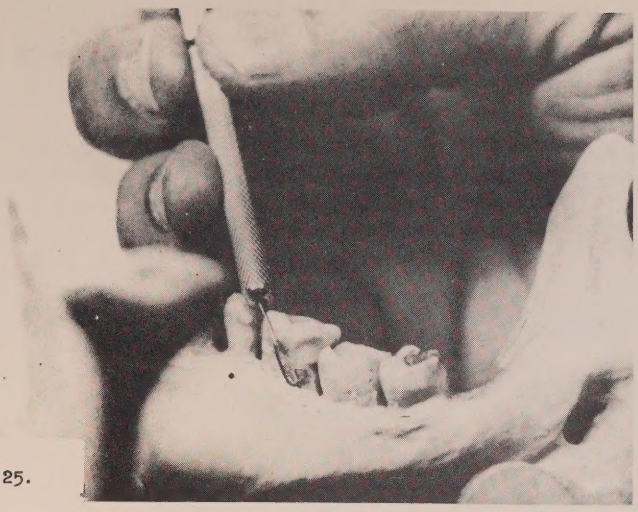


Fig. 25.

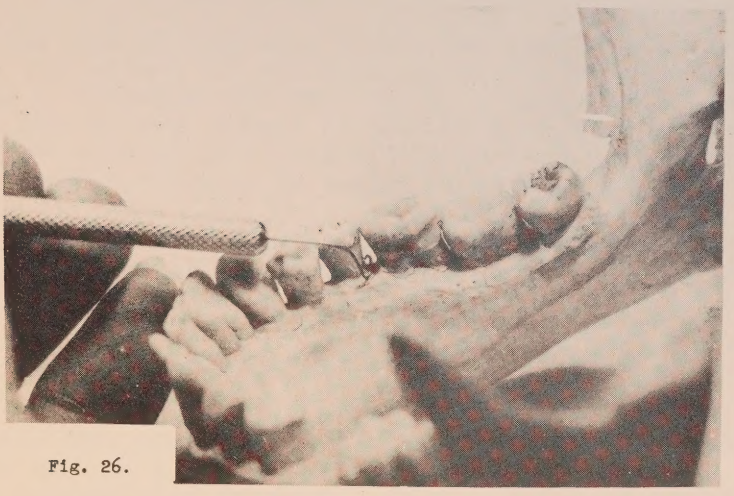


Fig. 26.

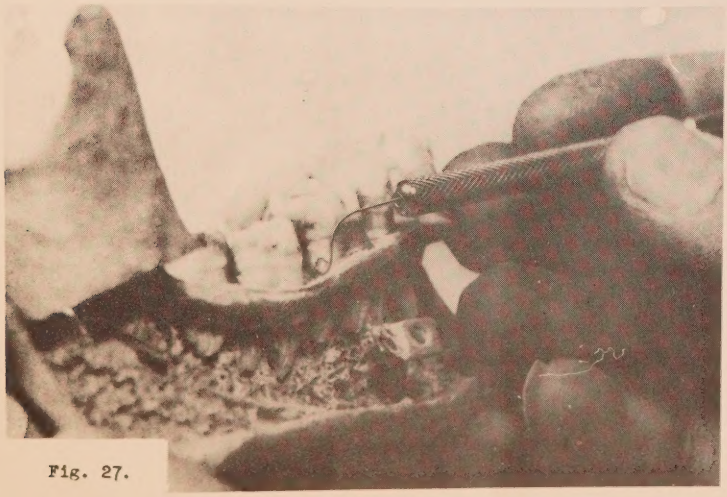


Fig. 27.

APPENDIX "L"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides.

Grantee: Dr. J.J. Rae

Project No. DR 1 Amount of Grant: $1,000

SUMMARY OF WORK

(a) Chemical Mechanisms involved in Dental Caries (with C.T.Clegg)

A major portion of the work since the last report has been spent on the effect of ammonium salts on acid production by saliva in a suitable medium. We have been unable to duplicate the inhibitory effect of ammonium salts observed by Kesel. The possibility that a proteolytic enzyme may exert an inhibitory influence is being investigated.

Further work has been done on the application of Armstrong's fluorine determination and this method seems to yield satisfactory results.

(b)Phosphatase in Saliva (with J.T.Dentay)

In an attempt to investigate the characteristics of salivary phosphatase the possibility has arisen that the phosphatase in saliva may be a bacterial phosphatase due to the lactobacillus acidophilus present. This problem is being investigated and some progress has been made.

February,
1 9 4 8 .

APPENDIX "I"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides.

Grantee: Dr. A.J. Rae

Project No. DR I Amount of Grant: $1,000

SUMMARY OF WORK

(a) Chemical Mechanisms Involved in Dental Caries (with C.T. Olsen)

A major portion of the work since the last report has been spent on the effect of ammonium salts on acid production by saliva in a suitable medium. We have been unable to duplicate the inhibitory effect of ammonium salts observed by Kesel. The possibility that a proteolytic enzyme may exert an inhibitory influence is being investigated.

Further work has been done on the application of Armstrong's fluorine determination and this method seems to yield satisfactory results.

(b) Phosphatase in Saliva (with J.T. Dowty)

In an attempt to investigate the characteristics of salivary phosphatase the possibility has arisen that the phosphatase in saliva may be a bacterial phosphatase due to the lactobacillus acidophilus present. This problem is being investigated and some progress has been made.

February,
1 9 4 5 .

APPENDIX "L"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: The chemical mechanism of dental caries.

Research Workers: James J. Rae
Charles T. Clegg
John T. Dentay

Institution: Department of Chemistry,
University of Toronto

Since our last report the work done has dealt with the following:-

(1) Armstrong's Fluorine Method

(2) Experiments in an attempt to investigate the results of Kesel and O'Donnell mentioned in Report No.3, and

(3) Salivary Phosphatase.

(1) The method proposed by Armstrong (J.I.E.C., Anal.Ed. 8: 384) has been used satisfactorily. This method involves distillation of the fluorine as fluosilicate and subsequent titration with thorium nitrate. Its useful range is 1-10 gamma of F.

(2) According to Kesel, O'Donnell, et al (J.A.D.A. 33:695.1946) a factor inhibiting acid production of saliva and lactobacillus acidophilus growth is developed in caries-immune saliva on standing. No such factor was found in caries-active saliva. They regarded ammonium salt as the factor responsible for this inhibition.

(a) In an attempt to investigate this interference with acid production sodium acetate, ammonium acetate and in some cases ammonium carbonate were added to beef broth (4 ml.), glucose (1 ml. of 2%) and caries-active saliva (1 b.a. count 840,000) (1 ml.). After a period of 24 hours at 37° the pH dropped from about 7.0 to about 4.0 in all tubes showing no inhibitory effect of the ammonium salt in the concentrations used (20 - 200 mg%).

Incubation of the beef broth with the ammonium salts at 37° for 18 hours before the addition of saliva and nutrients produced the same result as above i.e. no inhibition in acid production.

Two filtrates prepared from caries-immune and caries-active salivas were prepared according to the method of

Kesel and O'Donnell. Equal volumes of saliva and beef broth were incubated for 8 days, and then filtered through a fine fritted glass funnel. 3 ml. of these filtrates, 3 ml. of caries-active saliva and 1 ml. of 2% glucose were incubated for 24 hours at 37° and the pH dropped from 7.5 to 4.4 in both cases indicating no inhibitory factor in these filtrates.

(b) Since the acid production is due to the activity of lactobacillus acidophilus it was thought advisable to attempt to repeat Kesel and O'Donnell's work on the growth-inhibiting factors in caries-immune saliva. The assistance of Miss Berry of the Faculty of Dentistry made this work possible.

Eight-day caries-immune and caries-active saliva filtrates, prepared as described above, were inoculated with lactobacillus acidophilus cultures, incubated for 24 hours and plated out. After 4 days the lactobacillus acidophilus count was approximately 300,000 for both salivas, showing no inhibitory factor present in caries-immune saliva.

Beef broth solutions containing added (1) Ammonium acetate, (2) Ammonium carbonate, and (3) sodium acetate as a control were inoculated with lactobacillus acidophilus culture. 0.1 ml. of each was transferred immediately to solid agar and another 0.1 ml. plated out after 24 hours incubation at 37°. All six plates showed vigorous bacterial growth. The bacteria were stained, washed and identified as lactobacillus acidophilus.

The experiments described in 2(a) and 2(b) were attempts to duplicate the work of Kesel in which an inhibitory effect was observed in caries-immune saliva and which he attributed to ammonium salts. We have been unable to observe any such inhibition.

(c) In an attempt to find explanations for this lack of agreement we thought it possible that the beef broths used might differ since they are prepared from animal products whose properties might vary considerably. This variation would in all probability be found in the protein content of the broth. Another possible explanation is that the ammonium salts to which Kesel attributed inhibitory properties and which we found had no effect may be merely the by-products or end-products produced by the active inhibitory agent. If this is so, the inhibitor could conceivably be a protein, an amino acid or a proteolytic enzyme. A third minor difference in the procedures used is the stage in the experiment at which autoclaving of the beef broth took place i.e. before or after adding the ammonium salts.

In view of the fact that Kesel has shown that salivas vary in their amino acid content it was thought advisable to

investigate the amino acid content of salivas in relation to their lactobacillus acidophilus count. Srensen's Formol Titration (Bio.Zeit.,7:45. 1907; Zeit.Physiol.Chem.,64:120, 1909) was tried in an attempt to measure the total amino acid content of saliva with unsatisfactory results probably because of the low concentration of amino acids in saliva. If this work is to be continued it seems advisable to use either the Van Slyke Method or the microbiological method for estimating amino acids.

In view of the possibility that proteolytic enzymes may be the inhibiting factor, it was thought advisable to investigate the effect on acid production of a well-known protein enzyme preparation - Pancreatin (B.D.H.). The activity of this enzyme was measured by its hydrolytic effect on casein in which reaction the casein, originally precipitated by acetic acid, is converted into a soluble material after one hour at 37°. An active pancreatin solution was shown to have no effect on acid production by saliva in a beef broth and glucose medium.

A preliminary experiment with 'merthiolate' (Lilly) showed that this substance which is a potent bacteriacide did not interfere with acid production by saliva in glucose and beef broth medium. In the tubes containing only pancreatin and beef broth the pH dropped from 7.0 to 4.0 indicating the probable formation of amino acids. 'Merthiolate' interfered with the acid production in this case.

The investigations on the amino acids and proteolytic enzymes are being continued with a view to clearing up the differences between Kesel's work and ours and also with the hope that these experiments will shed new light on the proteolytic enzyme theory of dental caries.

(3) (i) A method for determination of presence of phosphatase was adapted from the work of several earlier researchers. It was decided that (at first) the amount of the phosphatase would be determined by the quantity of di-sodium phenyl phosphate hydrolyzed in M/20 solution, per unit time at a given pH. To determine the amount of substrate hydrolyzed, several methods of analysis were tried and discarded. The two methods finally adopted were both colorimetric. One was an adaptation of King's method of determining inorganic phosphate, the other Folin-Ciocalteau's method for the determination of free phenol. It was felt that with these two methods an accurate determination of the extent of hydrolysis was possible. To control the pH of these experiments it was necessary to use buffers not containing phosphates. Thus, for the acid regions a Veronal-Na Acetate buffer, for the basic, a Veronal-Carbonate buffer was used.

(ii) Salivas of different origins were treated in several ways, resulting in the interesting possibility of the non-existence of salivary phosphatase. At the present it appears that the phosphatatic activity of saliva is due to bacterial phosphatase, probably mainly produced by Lactobacillus Acidophilus.

(iii) With the cooperation of Miss Berry, of the Department of Dentistry, and with the help of a strain of L.B.A. received from "Borden", several cultures of L.B.A.were started. The aim of this is to produce a "synthetic saliva", which would have only known constituents and would contain a number of L.B.A. corresponding to the number considered as average among human salivas. In order to be able to keep the enzymes and bacteria in a frozen state, it was found advisable to purchase a refrigerator, with deep freeze chamber, (until the arrival of this equipment the bacteriological work had to be carried out at the Dental Building). This latter phase of the problem at hand is a slow one, as it depends now not only on the somewhat independable human factor, but also on the great independability of bacterial growth and activity. In this respect, L.B.A. is known to be a difficult actor.

(iv) The three preceding paragraphs cover in broad lines the work done on the problem between October 25th, 1947, and January 31st, 1948.

SUMMARY

The research under this project during the past year has been devoted to (1) an attempt to find chemical differences between caries-immune and caries-susceptible salivas and (2) a study of phosphatase in saliva.

Under the first subdivision it has been found necessary (a) to investigate the claims of Karshan (J.D.R. 15: 383.1936) that caries-immune salivas lose more calcium and less phosphate when shaken with solid tricalcium phosphate than caries-active salivas. We found that the differences in the concentrations of these constituents under this treatment depended on the pH of the salivas used and in all cases the phosphate increased. Inorganic salt solutions containing calcium nitrate and sodium phosphate exhibited an analogous effect (Rae and Clegg, J.D.R.,27:54. 1948).

(b) To investigate the claims of Kesel and his colleagues that ammonium salts inhibit the growth of lactobacillus acidophilus and acid production by saliva in a glucose medium. We have been unable to substantiate these results but in an attempt to find such an inhibitory factor we are at present investigating proteolytic enzymes and amino acids.

(c) A paper by Eggers-Lura in J.D.R.,26:203.1947, presented results of saliva analyses so different from those observed in our laboratory by Miss Muriel Davies (Section C of Progress Report No.4) that a letter sent to the editor of the Journal pointing out their discrepancies has been transmitted to Dr. Eggers-Lura. As yet no reply has been received.

(d) Mr. Clegg presented a paper at the Caries Conference convened by Dean Ellis of the Faculty of Dentistry, University of Toronto, on December 18, 1947, in which he presented some of the more significant of our findings.

Under the second subdivision Mr. Dentay has done some very good work on the estimation of the phosphatase activity of saliva. From his results we have reason to believe that the phosphatase activity of saliva may be due to bacterial phosphatase.

PROPOSED WORK

1. To continue investigating chemical differences between caries-immune and caries-active salivas.

2. To study the origin and characteristics of the phosphatase in saliva.

APPENDIX "M"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Chemical study of nitrous oxide for dental anaesthesia.

Grantee: G.H.W. Lucas

Project No.: DR 2 Amount of Grant: $1900.

SUMMARY OF WORK

The literature contains conflicting reports concerning the oxygen saturation of the blood of patients under nitrous oxide anaesthesia during dental surgery. In a previous report, it was shown that a number of anaesthetic gas machines in a series tested, were faulty in that they failed to deliver the percentage of oxygen in nitrous oxide as was indicated on the dial setting recorder. In most instances workers reporting on gas-oxygen anaesthesia trusted the dial setting recorder for the percentage of oxygen in the gas inhaled by the patient.

It was considered advisable therefore to check the oxygen saturation of the blood of patients under gas-oxygen anaesthesia during dental surgery, analysing the alveolar air at the same time as the oxygen saturation of the blood was determined. Such analyses are all the more necessary, since in dental surgery the use of a nose mask may permit the inhalation of air with the gas from the gas machine and a higher oxygen content may be present than indicated by the dial setting recorder. The oxygen saturation of the blood may be determined rapidly and accurately by the use of an oximeter;

APPENDIX "M"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Chemical study of nitrous oxide for dental anaesthesia.

Grantee: G.H.W. Lucas

Project No.: DR 2 Amount of Grant: $1500.

SUMMARY OF WORK

The literature contains conflicting reports concerning the oxygen saturation of the blood of patients under nitrous oxide anaesthesia during dental surgery. In a previous report, it was shown that a number of anaesthetic gas machines in a series tested, were faulty in that they failed to deliver the percentage of oxygen in nitrous oxide as was indicated on the dial setting recorder. In most instances workers reporting on gas-oxygen anaesthesia trusted the dial setting recorder for the percentage of oxygen in the gas inhaled by the patient.

It was considered advisable therefore to check the oxygen saturation of the blood of patients under gas-oxygen anaesthesia during dental surgery, analyzing the alveolar air at the same time as the oxygen saturation of the blood was determined. Such analyses are all the more necessary, since in dental surgery the use of a nose mask may permit the inhalation of air with the gas from the gas machine and a higher oxygen content may be present than indicated by the dial setting recorder. The oxygen saturation of the blood may be determined readily and accurately by the use of an oximeter;

gas analyses require much more time. The small Beckman oxygen analyser appeared to be the most useful instrument for analyses of alveolar air. Much time was wasted with the first one purchased because it proved to be defective. The second one gave check analyses with air and oxygen-nitrous oxide mixtures with accuracy as claimed by the instrument makers. Nothing was known, however, about the behaviour of the Beckman oxygen analyser when CO_2 in concentrations found in alveolar air were present in gas for analysis. It was found that the analyser required well over 100 cc. of gas at times to flush out previously analysed gas and reach a steady state. Much difficulty was experienced in preparing samples of CO_2, N_2O and O_2 of definite composition. If such samples were prepared in a gasometer over liquid some of the gases dissolved; if they were prepared in rubber bags the N_2O passed out rapidly through the rubber. It is absolutely essential that the gas analyser record accurately the oxygen percentage in alveolar air. Therefore, the analyser must be checked from time to time with a standard mixture of CO_2, N_2O and O_2. Much persuasion was required to induce a mechanic to attempt pumping these gases under pressure into a suitable tank, because of the danger of an explosion.

At the present time two tanks with somewhat different mixtures of CO_2, O_2 and N_2 have been prepared and are being analysed by means of the Hempel pipette, the Cambridge analyser and the Beckman oxygen analyser.

CONCLUSIONS

If the Beckman oxygen analyser is sufficiently accurate the work on patients may begin at once, as all necessary preparations have been made.

February, 1948

APPENDIX "N"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Tissue toxicity and efficiency of local anaesthetics for topical application and nerve block in dentistry.

Grantee: E.A. Sellers.

Project No.: DR 19 Amount of Grant: $1300.

SUMMARY OF WORK

Dr. H.S. Hamilton has continued his investigation of a group of local anaesthetics. The systemic toxicity of cocaine, procaine, monocaine, butyn, pontocaine, metycaine, naphthocaine and octacaine has been studied by obtaining LD50 values in white mice. With the exception of pontocaine, they are all less toxic than cocaine, which was used as a standard for expressing the relative toxicity. In order of increasing toxocity they may be listed, procaine, metycaine, monocaine, naphthocaine, butyn, octacaine, cocaine, pontocaine. Intradermal injections in guinea pigs revealed that, with the exception of cocaine, the order of tissue toxicity closely paralleled that of systemic toxicity.

A colorimetric method of estimating corneal penetrability in rabbits eyes for certain local anaesthetics, is presented as part of a study of the factors involved in topical anaesthesia.

February, 1948.

APPENDIX "B"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Tissue toxicity and efficiency of local anaesthetics for topical application and nerve block in dentistry.

Grantee: E.A. Gallare.

Project No.: DR 19 Amount of Grant: $1500.

SUMMARY OF WORK

Dr. H.B. Hamilton has continued his investigation of a group of local anaesthetics. The systemic toxicity of cocaine, procaine, monocaine, butyn, pontocaine, metycaine, naphthocaine and octocaine has been studied by obtaining LD50 values in white mice. With the exception of pontocaine, they are all less toxic than cocaine, which was used as a standard for expressing the relative toxicity. In order of increasing toxicity they may be listed, procaine, metycaine, monocaine, naphthocaine, butyn, octocaine, cocaine, pontocaine. Intradermal injections in guinea pigs revealed that, with the exception of cocaine, the order of tissue toxicity closely paralleled that of systemic toxicity.

A colorimetric method of estimating corneal penetrability in rabbits eyes for certain local anaesthetics, is presented as part of a study of the factors involved in topical anaesthesia.

February, 1948.

APPENDIX "N"

Subject: Observations on the systemic and local tissue toxicity of eight local anaesthetics.

Authors: H. S. Hamilton and E. A. Sellers

Laboratory: Department of Pharmacology, University of Toronto.

Project No.: DR 19

Purpose: To study the general and tissue toxicity of local anaesthetics which are, or may be, of use in dentistry. The relative potency of such anaesthetics for topical application, infiltration and nerve block will be investigated. This progress report is chiefly concerned with toxicity data.

Procedure: In the search for less toxic, yet potent substitutes for cocaine, procaine and monocaine have proved most satisfactory for infiltration and block anaesthesia. As a consequence, they are used extensively in dental practice. They are poorly suited for topical anaesthesia and other compounds must be used for this purpose. The present study includes procaine and monocaine which are suitable only for injection; metycaine which can be used topically as well; and butyn, pontocaine and cocaine which are used chiefly for surface anaesthesia.

The two new drugs included in the series, naphthocaine and octacaine, appear to be useful for both purposes, although adequate clinical evidence is not yet available.

I. SYSTEMIC TOXICITY

In attempting to assess the systemic toxicity of any local anaesthetic in the laboratory, a number of factors have to be considered. Among these are (a) the species of animal or animals used, (b) the method of introducing the drug into the animal, (c) physical condition of the test animals, (d) the environmental temperature and (e) the method of recording the results.

The white mouse has been used in the past to a large extent for assessing the systemic toxicity of many drugs and appears to be a satisfactory animal for this purpose. However, too much reliance cannot be placed on the results obtained from using one species of test animal and other larger animals, such as the guinea pig, white rat, and rabbit have also been utilized.

Until recently, the subcutaneous and intravenous routes of administration have been those most commonly used. Intraperitoneal injection, resulting in an intermediate rate of absorption into the blood stream, has now been adopted as a third method of administering the drug.

For obvious reasons only healthy animals should be used. T.H. Rider (1) in 1930, working with frogs, found that seasonal variations in the condition of the frogs altered the time values obtained for anaesthetizing the sciatic nerve. Also Sievers and McIntyre (2) showed that the environmental temperature altered the toxicity figures obtained for procaine injected into white mice. Much less of the drug on a basis of body weight was needed to produce lethal effects at a high environmental temperature than at a low one.

With so many possible variable factors involved, it is not surprising that in the earlier literature the toxicity figures of various authors do not show much agreement.

Some uniformity was introduced to toxicity studies by using the "LD50" as a reference standard for comparison of one drug with another. This unit may be defined as the amount of the anaesthetic drug in milligrams per kilogram of body weight necessary to kill 50% of a given population of animals, and should be qualified by the animal used and the route of administration. An "LD50" of a local anaesthetic is of most value when compared with those of commonly used drugs (e.g. cocaine or procaine) the toxic and anaesthetic properties of which are well known. Taking cocaine or procaine as a basis for comparison and assigning a value of 1, relative toxicity figures can be calculated for the unknowns.

In this study, white mice, weighing from 20-25 grams were used as the test animals and the drugs were injected via the intraperitoneal route. Doses were calculated on a weight basis. The results are shown in Table I.

Relative toxicities are calculated in Table II, using cocaine as a basis and assigning it a value of 1. It will be seen that, with the exception of pontocaine, all the anaesthetics used have a relative value of less than unity, indicating that by the intraperitoneal route in white mice they are less toxic than cocaine.

Toxic signs which occurred were similar for all the drugs but pontocaine, which appeared to produce more violent and prolonged tonic and clonic convulsions.

A preliminary mild excitement stage was apparent in which the animal became hyperactive. This was accompanied by tachycardia. Soon the hind legs began to drag, and this was followed almost at once by an apparent loss of equilibrium, the animal falling over on its back or side. The onset of convulsions was accompanied by irregular heart action. Slow gasping respiration appeared after a period of convulsive activity before death ensued. Respiratory failure occurred before circulatory collapse.

II. TISSUE TOXICITY

In evaluating the tissue toxicity of these anaesthetic compounds, intradermal injections were made on the backs of guinea pigs. The skin of the rabbit was found to be too thin and lax for the purpose. This method appears preferable to that of instilling drops in the eyes of rabbits. A definite amount can be injected intradermally, while in the instillation procedure, blinking, and the effect of dilution with lacrymal secretions causes some loss in volume and concentration. Intradermal tissue reactions should resemble closely those produced in actual practice by infiltration or nerve block.

In assessing the tissue reactions in this study, the guinea pigs were prepared as follows:- The hair was clipped from an area roughly 2 inches by 3 inches on the back and the stubble removed with a depilatory cream. Calamine lotion was then applied to allay irritation, and after an interval of several hours, or sometimes overnight, the intradermal injections were made.

One animal was used for each anaesthetic drug and injections of 0.2 cc. of 0.1%, 0.25%, 0.5%, 1.0%, 2.0% and where applicable, 5.0% were made. A control injection of normal saline was also included. The varying reactions consisted of different degrees of erythema or the appearance of haemorrhagic spots with ulceration and crust formation in some cases. After the injections, observations of the gross reactions were made at intervals of 1/2 hour, 1 hour, 4 hours, 3 days, 1 week and 3 weeks. For easy comparison, water colour reproductions of the observed reactions were made on suitable forms.

The results are shown in Table III. Also shown is the order of the various anaesthetics in decreasing LD50 values (increasing systemic toxicity) from top to bottom.

From an inspection of the Table it can be seen that the two lists run practically parallel with the exception of cocaine, which shifts from a position indicative of marked systemic toxicity to an intermediate position in the order of tissue toxicity.

III. TOPICAL ANAESTHESIA

Although topical anaesthesia was first demonstrated on the cornea in animals by Koller in 1884, it was soon found that other mucosal surfaces could be similarly anaesthetized. Procaine has withstood the test of time as an infiltrative or block anaesthetic but fails to produce adequate surface anaesthesia when instilled in the eye or applied topically to mucous membranes. Similar properties are possessed by other synthetic

anaesthetics. It has been found that most compounds producing a quick and adequate corneal anaesthesia will act similarly when applied locally to mucosal surfaces.

Topical anaesthetics in clinical use to-day vary considerably in the depth and duration of the anaesthesia produced. Until recently, these differences as far as the eye is concerned, were attributed to differences in the rate of diffusion which, in turn, were thought to be influenced by a variety of factors, including pH, osmotic pressure, molecular size, variations in intraocular pressure and the presence of abrasions of the epithelium.

Swan and White (4) in 1942 investigated this problem of corneal permeability and concluded that a simple diffusion process was not solely responsible but that molecular structure and resultant physical properties profoundly affected the rate of penetration of local anaesthetic compounds into the cornea. This latter fact had hitherto been completely overlooked in studying topical anaesthesia.

Swan and White obtained their values for corneal permeability by running a continuous stream of the anaesthetic over the cornea of an anaesthetized rabbit for 3 minutes, then rapidly excising the cornea and extracting the test substance with water and varying dilutions of ethyl alcohol.

The rate of penetrability of local anaesthetics through the cornea might be estimated by measuring the concentration of the anaesthetic in the aqueous humour after applying it to the cornea for a given length of time. The amount of anaesthetic present in the aqueous would be modified by a number of factors, such as the rapidity of removal from the anterior chamber through the filtration angle, absorption from the aqueous via the blood vessels of the iris, vascularity of the corneoscleral region and passage of the drug into the lens and vitreous. One might expect that the sum of these factors would be about equal in healthy animals and that any quantitative differences obtained with different anaesthetics could be attributed to differences in the rate of penetration.

In this study a micromodification of the Bratton and Marshall (5) colorimetric method, applicable to the small amounts of aqueous humour available (abour 0.2 cc. in rabbits eyes) was evolved (see Appendix I). Some preliminary estimations were made using procaine and tutocaine, which differ markedly in their ability to produce corneal anaesthesia.

Using known dilutions of these two drugs, standard curves were plotted; 2.0% procaine in distilled water was applied to a rabbitt's eye for 5 minutes and, after washing the excess from the conjunctival sacs, the aqueous was quickly withdrawn using a fine (No. 27) hypodermic needle.

After colorimetric estimation on an Evelyn photoelectric colorimeter, the amount of local anaesthetic present in the 0.2 cc. sample of aqueous was calculated using the standard curve.

Following the above procedure, 10 estimations were made and an average of 0.29 micrograms of procaine hydrochloride was found in each 0.2 cc. of aqueous humour.

Similar calculations for tutocaine gave an average figure of 0.22 micrograms.

This is rather surprising in view of the fact that procaine is a poor topical anaesthetic, while tutocaine is a good one.

Further work is planned to clarify the significance of these and similar values.

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4. Swan,K.C. and White, N.G. - Am.J.Ophthal. 25. Series 3. 1043. 1942.

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TABLE I

Intraperitoneal LD50 for White Mice

Dose mg./kg.	No.of animals used	Animals Survived/Died	LD50 from graph	Comparable figures from literature
		Cocaine		
65	10	6/4	70	85, 100
80	10	3/7		
87	10	2/8		
		Procaine		
170	10	8/2	185	330, 450, 123
190	10	4/6		
200	5	1/4		
		Monocaine		
170	10	7/3	175	203
175	10	5/5		
180	10	4/6		
190	10	0/10		
		Metycaine		
150	10	8/2	185	
170	10	6/4		
195	10	4/6		
		Butyn		
80	10	6/4	90	
90	10	5/5		
100	5	0/5		
		Naphthocaine		
90	10	10/0	120	140
110	10	7/3		
120	6	3/3		
130	6	1/5		
		Octacaine		
70	10	8/2	80	85
80	10	5/5		
85	10	4/6		
90	10	3/7		
		Pontocaine		
50	10	8/2	52	70
55	10	1/9		
60	10	0/10		

TABLE I

Intraperitoneal LD50 for White Mice

Dose mg./kg.	No. of animals used	Animals Survived/Died	LD50	From Comparable Figures From Literature
		Cocaine		
65	10	8/2	70	85, 100
80	10	3/7		
87	10	2/8		
		Procaine		
170	10	8/2	185	390, 450, 182
190	10	4/6		
200	5	1/4		
		Monocaine		
170	10	7/3	175	202
175	10	5/5		
180	10	4/6		
190	10	0/10		
		Metycaine		
170	10	8/2	185	
170	10	6/4		
195	10	4/6		
		Butyn		
80	10	6/4	90	
90	10	5/5		
100	5	0/5		
		Naphthocaine		
90	10	10/0	120	144
110	10	7/3		
120	9	5/4		
130	6	1/5		
		Optocaine		
70	10	8/2	80	80
80	10	5/5		
85	10	4/6		
90	10	3/7		
		Pantocaine		
50	10	8/2	52	70
55	10	4/6		
60	10	0/10		

TABLE II

Drug	LD50	Relative toxicity based on cocaine
Cocaine	70	1.0
Procaine	185	0.378
Metycaine	185	0.378
Monocaine	175	0.400
Naphthocaine	120	0.583
Butyn	90	0.777
Octacaine	80	0.875
Pontocaine	52	1.346

TABLE II

Drug	LD50	Relative toxicity based on cocaine
Cocaine	70	1.0
Procaine	185	0.378
Metycaine	185	0.378
Nonocaine	175	0.400
Naphthocaine	120	0.583
Butyn	90	0.777
Octacaine	80	0.875
Pantocaine	52	1.346

TABLE III

LD50 values from Table I in decreasing order of magnitude		Order of tissue toxicity from least irritant to most irritant
Procaine	185	Procaine
Metycaine	185	Monocaine
Monocaine	175	Metycaine
Naphthocaine	120	Cocaine
Butyn	90	Naphthocaine
Octacaine	80	Butyn
Cocaine	70	Octacaine
Pontocaine	52	Pontocaine

TABLE III

	LD50 values from Table I in decreasing order of magnitude	Order of eleven toxicity from least irritant to most irritant
Procaine	185	Procaine
Metycaine	185	Monocaine
Monocaine	175	Metycaine
Diphthocaine	120	Cocaine
Butyn	90	Nephthocaine
Octacaine	80	Butyn
Cocaine	70	Octacaine
Pontocaine	52	Pontocaine

SCHEDULE I

Standardized test tubes of correct size for the Evelyn photoelectric colorimeter were used.

PROCEDURE

1/2 cc. of 4 N H_2SO_4 placed in test tube and the 0.2 cc. sample of aqueous humour added.

Add 1/4 cc. of 0.1% sodium nitrite. Wait 3 minutes.

Add 1/2 cc. of 95% ethanol. Wait 2 minutes.

Add 1/4 cc. of 0.1% N-(1-naphthyl) ethylenediamine dihydrochloride. The colour develops rapidly. Wait 5 minutes to ensure full development of colour. Add 6 cc. distilled water to bring total volume to a sufficient height in the tube for use in the apparatus.

A blank mixture of the above reagents in the stated amounts and percentages produces a stable solution.

SCHEDULE I

APPENDIX "O"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario.

Grantee: M. Doreen Smith

Project No. DR 13 Amount of Grant: $1050

SUMMARY OF WORK

A quantitative relationship has been established between fluorine and lactic acid produced by the microorganism L. acidophilus. It was decided to use this inhibition by fluorine as a basis of assay, although such techniques are usually based on accelerating factors.

It was found that L. acidophilus selected could be grown at a pH of 5.0. This was important since a recent study showed fluorine did not inhibit acid production of microorganisms, until pH 5.0 was reached. L. casei in a medium of pH 6.8 had previously been tried by us without success. Using L. acidophilus grown in broth and following a standardized procedure, a linear relationship was seen to exist between the lower concentrations of fluorine and the titratable acidity.

Since it was felt that a synthetic medium rather than broth should be used, a provisional medium, essentially the same as for L. casei was employed. The organism grew well in this and responded to varying concentrations of fluorine.

After a series of experiments on varying the buffers, sodium acetate buffer was chosen as satisfactory.

Preliminary experiments are under way on molar samples of extracted teeth.

February,
1 9 4 8 .

APPENDIX "A"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario.

Grantee: M. Dorsen Smith

Project No. DR 13 Account of Grant: $1000

SUMMARY OF WORK

A quantitative relationship has been established between fluorine and lactic acid produced by the microorganism L. acidophilus. It was decided to use this inhibition by fluorine as a basis of assay, although some techniques are usually noted to accelerating factors.

It was found that L. acidophilus selected could be grown at a pH of 5.0. This was important since a tenant study showed fluorine did not inhibit acid production of microorganisms until pH 5.0 was reached. L. casei in a medium of pH 6.7 had previously been tried by us without success. Using L. acidophilus grown in broth and following a standardized procedure, a linear relationship was seen to exist between the lower concentrations of fluorine and the titratable acidity.

Since it was felt that a synthetic medium rather than broth should be used, a provisional medium, essentially the same as for L. casei was employed. The organisms grew well in this and responded to varying concentrations of fluorine.

After a series of experiments on varying the buffers, sodium acetate buffer was chosen as satisfactory.

Preliminary experiments are under way on molar samples of extracted teeth.

February,
1948.

APPENDIX "O"

REPORT TO ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario.

Grantee: Dr. M. Doreen Smith

Project No. DR 13 Amount of Grant: $1050.

REPORT

The basis of our investigation was as follows: Fluorine is an enzyme inhibitor and has been shown to inhibit the acid formation of lactic acid bacteria. It is probable that fluorine interferes with the transformation of the Cori and Robison esters as shown by Broh-Kahn and Mirsky (1) and the dehydrogenase system as shown by Clapper (2). At any rate in 1940, Bibby and Van Kestern (3) found fluorine concentrations of less than 1 p.p.m. to limit acid production of oral bacteria. In 1942 Levin (4) suggested that extremely small amounts of fluorine of the order of 0.1 p.p.m. may have a marked effect on bacteria acid production.

The organism selected was Lactobacillus acidophilus. The reasons being that Fosdick and Stark (5) had shown that this organism will degrade glucose according to the Myerhoff scheme to lactic acid. The organism could be grown at a pH of 5.0 as shown by Jay. This detail was extremely important, for we had found no inhibition of lactic acid production by low concentrations of fluorine at a pH of 6.8 using a strain of L. casei. These observations were confirmed by the report of Rahn (6) who found no inhibiting activity of fluorine on acid production of microorganisms until pH 5.0 was reached. Also it seemed logical to use L. acidophilus as it appears to play an important role in dental caries. The organisms were obtained through the cooperation of Miss Berry of the Faculty of Dentistry. These had been cultured on a 1% tomato juice agar after being obtained from mouths of clinic patients with active dental caries, and appeared as small pleomorphic bacilli. A 1% dextrose broth of pH 5.0 (Jay's broth) was inoculated with a loopful of a typical colony. Stock cultures of the organism were maintained in 1% tomato juice agar stabs and kept at a low refrigerator temperature.

The inoculum was prepared from a fresh culture of L. acidophilus grown for 24 hours in 10 ml. of glucose broth at

37.5°C. At the end of this period the flocculent growth was centrifuged. The supernatant liquid was poured off and the bacteria sediment re-suspended in 5 ml. of sterile normal saline. One tenth ml. of the thoroughly mixed suspension was added to the previously set up media tubes. The tubes were then incubated at 37.5°C for seventy-two hours which was accepted as a standard incubation period. The acid formed by the microorganisms was titrated directly with 0.05N NaOH after the addition of ten drops of phenolpthalein. The end point was the first faint pink. The burette was graduated to read 0.01 ml.

Standard fluoride solution was prepared from C.P. sodium fluoride dried at 150°C for twenty-four hours. The stock solution contained 0.01% fluorine per ml. or 100 p.p.m., and from this solution dilutions were made containing smaller amounts of fluorine.

The above fluorine solution was added in 1 ml. portions in appropriate concentration to 4 ml. of the broth medium. The contents were well mixed, the tubes plugged and autoclaved for fifteen minutes at fifteen pounds pressure. Tubes were allowed to cool and equilibrate to room temperature. Each was inoculated as shown above and incubated for seventy-two hours. The titratable acidity in each was determined, as shown in the attached graph. It is worth noting that a linear relationship exists in the lower concentrations of fluorine. The results have been independently checked by Miss Mary Ham who is also working on fluorine analysis.

A study of synthetic media was begun, since it was desirable to determine the response of the assay bacteria L. acidophilus on a basal diet containing known nutrients. A provisional medium was employed, essentially the same as that used for L. casei. It was found that at the low pH of 5.0 our strain of L. acidophilus grew well, and responded to varying inhibitory concentrations of fluoride.

As the relative changes in hydrogen ion are a function of the buffering effect of the medium and also the titratable acidity of the bacteria, the effect of citrate and acetate buffer was determined. Both were found to be equally good with respect to acid production. The acetate buffer was selected since it is thought to be required by the lactic acid organisms.

With a view to using the above technique for microbiological analyses of fluorine in teeth, preliminary investigations have been initiated on molar samples of extracted teeth obtained from the Toronto General Hospital.

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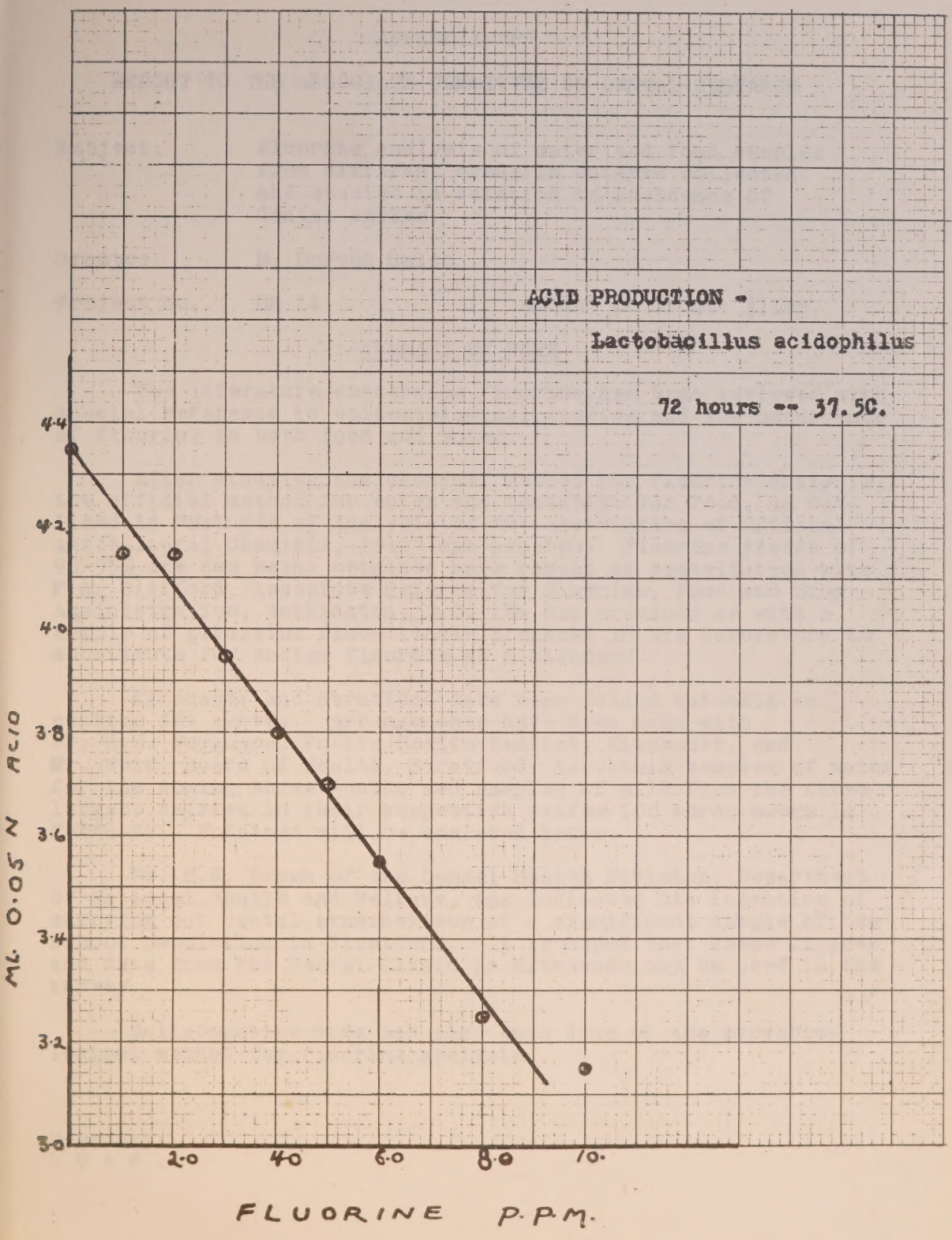
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Lactobacillus acidophilus
72 hours -- 37.5C.
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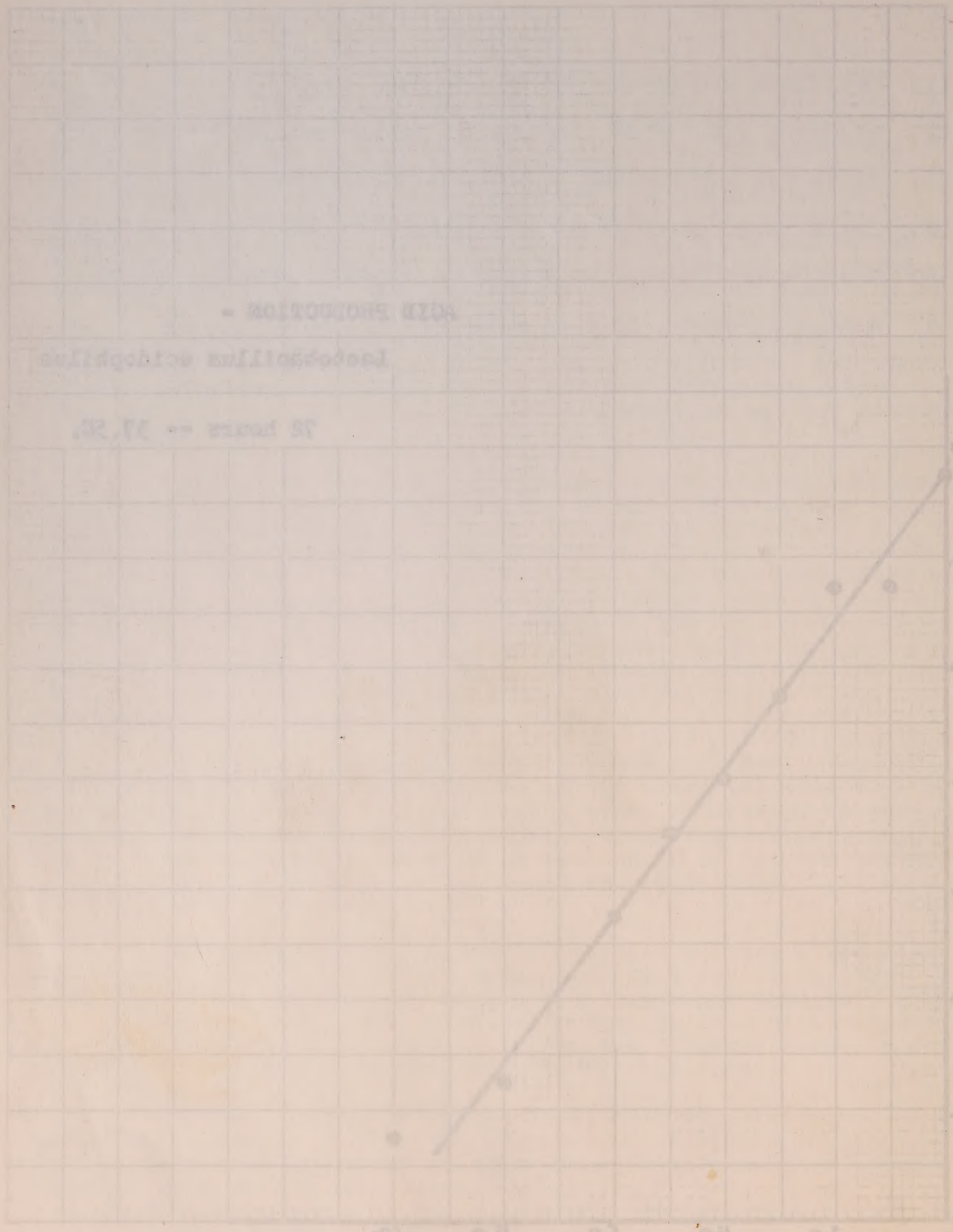

APPENDIX "P"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries.

Grantee: M. Doreen Smith

Project No. DR 14 Amount of Grant: $1125.

SUMMARY OF WORK

The literature concerning fluorine has been reviewed with special reference to epidemiological studies and the occurrence of fluorine in both food and water.

After studying the chemical method for fluorine analysis, the official method for water and tentative for food, as outlined in "Methods of Analysis of the Association of Official Agricultural Chemists, 1945" was adopted. Fluorine yields of 90-95% are now being obtained as a result of consultation with P.A. Clifford, Associate Referee for Fluorine, Food and Drug Administration, Washington, D.C. He has provided us with a sample of potassium fluosilicate prepared in his laboratory to substitute for sodium fluoride as a standard.

Kitchener and Stratford have been judged suitable as centres for survey. Arrangements have been made with Dr. R.H. Ferguson, Public Health Dentist, Kitchener, and Mr. Weis, Board of Health, Stratford, to obtain samples of water for the coming three months and samples of milk from the three largest dairies in their respective cities for three weeks in February. Potatoes will be analyzed later.

Dr. H.K. Brown of the Dental Health Division, Department of National Health and Welfare, has indicated his intention of carrying out dental examinations of a significant sample of the school population in Stratford. It is hoped that these figures and data from the Dental Clinic in Kitchener may be used in the survey.

Collaborative work has also been done on the microbiological method for fluorine analysis.

February,
1 9 4 8 .

APPENDIX "P"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Fluorine analysis of water and food samples collected and studied in relation to incidence of dental caries.

Grantee: Dr. M. Doreen Smith

Project No. DR 14 Amount of grant: $1125.

REPORT

A review of the rather extensive literature concerning fluorine has been made, in order to obtain a comprehensive picture of the work which has been done and the possibilities for further investigation into the problem. A summary of the role of fluorine in nutrition has been completed (88 references) with special reference to epidemiological studies. The importance of both food and water in fluorine studies has been noted. The occurrence of fluorides in food is wide and variable, although the amounts are usually quite small as compared with that in water (tea and fish are interesting exceptions, however). McClure calculated that the normal mixed diet provided 0.3-0.5 mg. fluorine per day. The work on fluorine in food is quite limited and this is one of the ramifications of the fluorine problem which would seem to warrant further investigation.

The chemical method for fluorine analysis has been studied. Since the Willard and Winter method for determination of fluorine in 1933, there have been a number of modifications introduced to increase the accuracy of the analysis. Armstrong (Journal of Industrial and Engineering Chemistry, anal.8, 384. 1936) gave an average error of -2.0% in the recovery of 2 micrograms of fluorine and a lower limit in the vicinity of 0.4 micrograms fluorine. McClure (J.Ind. Eng. Chem.,anal.,11,171. 1939) doubts the sensivity of Armstrong's method and claims that the minimum quantity actually titrated in aliquots with reasonable accuracy was found to be about 5.0 micrograms of fluorine (largely because of the high blank).

The Association of Official Agricultural Chemists has done considerable work concerning fluorine analysis in recent years, investigating all aspects of the procedure-preparation of sample, distillation and titration. They have developed a method which considerably modifies previous methods and appears to give close to theoretical recoveries.

Most of the analyses of foods which have been done are not recent and in the Journal of the Association of Official Agricultural Chemists, May 1945, it is stated that older data

represents ordinary food as containing altogether too much fluorine, and gives some results of recent analyses done by its method.

Thus, the method for fluorine analysis as outlined in "Methods of Analysis of the Association of Official Agricultural Chemists, 1945", official for water and tentative for food, was adopted by us. There has been some difficulty in obtaining complete yields using known amounts of fluorine. Contact was made through correspondence with P.A. Clifford, Associate Referee for Fluorine, Food and Drug Administration, Washington, D.C., concerning fluorine recoveries. He advised the use of potassium fluosilicate solution as the standard rather than the sodium fluoride solution which we had been using and provided us with a sample especially prepared and standardized in his laboratory. Yields of 90-92% are now being obtained.

Assistance was obtained from Mr. Reid of the Connaught Laboratories as to the design of the survey. The cities of Kitchener and Stratford seemed suitable as centres of investigation, because of the fluorine content of their water supplies and their similar status economically etc. Arrangements have been made with Dr. R.H. Ferguson, Public Health Dentist, Kitchener, Ont., and Mr. J.E. Weis, Board of Health, Stratford, Ont., to obtain samples of water for the coming three months and samples of milk from the three largest dairies in their respective cities for three weeks in February. Potatoes from these two centres will be analyzed later. It would also seem advisable to make an analysis of the milk in the summer months.

Dr. H.K. Brown of the Dental Health Division, Dept. of National Health and Welfare has indicated his intention of carrying out dental examinations of a significant sample of the school population in stratford. It is hoped that data from the Dental Clinic in Kitchener may also be used in the survey, as suggested by Dr. Kohli of the Ontario Department of Health.

Collaborative work has also been done on the microbiological method for fluorine analysis.

APPENDIX "Q"

Report to the Associate Committee on Dental Research

Subject: Investigation and critical report on dental caries research.

Grantee: J. S. Bagnall

Project No.: DR7

SUMMARY

Purposes: Critical report on dental caries research.

Scope: Up to the present approximately 3250 books and articles have been reviewed. Of these some 1800 are included in the bibliography and precis notes extracted from these run to about 2400 pages (letter-size, double space). Balance of articles not included in the Bibliography are duplications, or for other reason not considered of sufficient interest and value for inclusion in the Bibliography. The survey is now practically completed up to and including January 1948 publications. The precis notes have been grouped, as far as possible, into divisions as: Saliva, bacteriology, fluorine, etc. A satisfactory indexing method has been discussed with other workers and is almost complete. Some little cross-referencing and other details remain, but the project is now nearly ready for work on the completed report. The above data will show that this is going to take some time, but am planning to push it actively as time permits. The Bibliography is now being changed to conform to the requirements of "The Canadian Government Editorial Style Manual".

Conclusions: The report should serve to point out some avenues for future work. Dental caries is a much more complicated problem than many investigators have seemed to realize.

Date: February 13, 1948.

APPENDIX "R"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: To study the effects of altitude acceleration and deceleration on oral tissues.

Grantee: Col. E. M. Wansbrough

Project No.: DR 6

SUMMARY OF WORK

Work on this project is proceeding very slowly at No. 1 KTS, Toronto. Unfortunately, Major Purdy can only devote his spare time to this subject of research, as he is required to maintain a full-time operating clinic. He has, however, made an extensive study of the literature published on Aviation Dentistry and has prepared a bibliography listing 106 articles.

No grant required.

Date: 20 February, 1948.

APPENDIX "S"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: A study of the use of periodontal cement packs in the prevention and treatment of disease of the supporting tissues of the teeth.

Grantee: H. K. Box

Project No.: DR 4

SUMMARY

Clinically we know that periodontal packs are effective on the treatment of the infection factor of periodontal disease. The purpose of this project is to investigate the therapeutic qualities of periodontal packs for the purpose of selecting suitable materials for the various conditions encountered in periodontal case management and developing suitable techniques for clinical use. With this knowledge periodontal packs can be used more intelligently and effectively.

Three formulae were selected: Formulae 1, 2 and 3. Largely these differ only in the physical characteristics of the mix. The mix of Formulæ No. 1 is smooth in texture, quite sticky, adhering well even to moist surfaces. The mix might be described as a paint. The mix of Formulae No. 2 is coarse in texture and is mixed to a consistency of putty. The mix of Formulae No. 3 is about halfway between Nos. 1 and 2 in texture and adhesiveness and is of such consistency that it will flow under finger pressure.

In Vitro and In Vivo Studies

From the in vitro studies it was found that the bacteriostatic ingredients in the powder have a negligible effect apart from the useful property of acting as a vehicle for the liquid. The bacteriostatic agent diffuses out of the cement pack through agar in sufficient bacteriostatic concentration at a rate of approximately 10 mins. on 24 hours. Experiments indicate that this diffusion from the pack continues at least to 35 days. The experiments were discontinued at that point as this period is far longer than would be necessary for clinical use.

The pack was tested against staphylococcus aureus, streptococcus viridens, Streptococcus haemolyticus, Micrococcus catarrhalis and Pseudomona aeruginosa. It was quite effective against all but the bacillus pyo.

The addition of 5 per cent of Sulphathiasole powder or penicillin to the mix did not add to the bacteriostatic properties' effect; in fact, the addition of the sulphathiasole seemed to reduce it slightly.

In Vivo Studies

In investigating the effect of packing on the organisms of the pocket, studies were carried out leaving the pack in place for times varying from 24 hours to one week. Various techniques for using the pack were tested.

The procedure used was as follows: Material taken from the depths of the pocket was carefully placed on slides in such a way as not to break up the organisms and allowed to dry in air. The smears were then stained according to Giemsa's method. They were carefully examined under oil, at least 30 fields being considered in thin preparation.

For practical purposes the microscopic findings were divided into three groupings: Those smears on which no organisms of the fusospirochetal group were found were called clinically sterile; those showing 1 or 2 organisms per field, almost clinically sterile and those with any of the group organisms in fair numbers, clinically septic. All before-treatment smears were clinically septic. After treatment, leaving the pack in place, 24 hours in 91 cases, 64 per cent were clinically sterile, 14 per cent almost clinically sterile and 22 per cent were clinically septic. Only those cases in which the pack remained firmly in place were included in these figures.

After some investigation we believed that the reason for the septic pockets after treatment was failure to bring the bacteriostatic agent in contact with the organisms at the base of the pocket in sufficient concentration for the required time.

Box has pointed out in his paper "Necrotic Gingivitis" that due to the thinness of the pocket, the nature of its contents and the presence of calcific deposits, convection currents have little bearing on oxygen distribution in the pocket and the diffusion rate is slow. Thus, in order for the bacteriostatic agent to be brought into contact with the organisms at the base of the pocket, either the pocket must be completely filled to the base with pack or the gingival pocket wall must be separated from the tooth to allow diffusion of the active agent to the base of the pocket.

Considerable difficulty was found in subjecting this hypothesis to experimental test. However, it was found that after the pockets were re-packed a second time in 41 cases 82.5 per cent were clinically sterile, 14 per cent almost clinically sterile, and only 2.5 per cent were clinically septic. As access to the pockets was greatly improved by the application of the first pack, this is indirect supportive evidence for the hypothesis.

On the basis of the in vitro and in vivo studies, and clinical experience, techniques for clinical use are suggested for the various conditions met with in the treatment of periodontal disease.

Dr. Box, Mr. O'Connell and I expect to have a complete report for the Council and a paper for publication completed shortly.

Signed: " W. J. Linghorne"

APPENDIX "T"

March 13, 1948.

National Research Council
Ottawa, Canada

Dear Sirs:

The Associate Committee on Dental Research recommends consideration of the desirability of establishing a small number of Dental Fellowships, similar in administrative procedure and in stipend to the existing Medical Fellowships granted by the Council.

It is the view of the Committee that it would hardly be possible to attract graduates in Dentistry by an extension of the Council's normal scheme of bursaries, scholarships, etc. The Committee recognizes the difficulty of appearing to discriminate as to stipend against graduates in Physics, Chemistry, Biology, and other branches of pure science. In this latter group, however, the holders of awards are normally proceeding towards a higher degree (M.Sc. or Ph.D.) which is an essential professional qualification for them and a milestone on the highway of their careers.

Graduates in Dentistry, as in Medicine, however, have already obtained their principal professional qualifications, and a year or more spent in research is often to some extent a detour in their careers. They have, moreover, usually spent more time and more money upon University education than graduates in science. The Associate Committee feels accordingly that fellowships for graduates in Dentistry should follow the plan already established in Medicine, and suggests that initially one Senior Fellowship at not over $2400. and two Junior Fellowships at approximately $1200. should be set up. This should not, of course, exclude the possibility of awarding bursaries, etc., under the Council's principal scheme, to graduates in pure science for programmes relevant to dental research, any more than the establishment of the special awards for medical graduates has interfered with the award of bursaries, scholarships, etc., to science graduates in Biochemistry, Bacteriology, and relative fields.

All of which is respectfully submitted.

Yours faithfully,

"Roy G. Ellis"

Roy G. Ellis, Chairman,
Associate Committee on Dental Research.

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COPY NO. 1

NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS

OF THE

FIFTH MEETING

OF THE

EXECUTIVE

OF THE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

OTTAWA

25 OCTOBER, 1948

Proceedings of the Fifth Meeting

of the

EXECUTIVE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in the Council Chamber, National Research Building,
9:30 a.m., 25 October, 1948.

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1. Attendance

Dr. R. G. Ellis, Chairman
Dr. E. Charron
Dr. R. H. McDougall
Dr. D. L. Thomson
Col. E. M. Wansbrough

Mr. S. J. Cook, Secretary

2. Chairman's Remarks

THE CHAIRMAN welcomed Dr. McDougall who had been appointed to membership of the Committee to complete the unexpired portion of Dr. Stibbs' appointment.

He said that at this meeting of the Executive several matters referred by the Committee would be dealt with and the agenda for the Committee meeting would be revised.

3. Items from the Proceedings of the 7th Meeting

(i) Dental Anaesthesia (Min. 7)

THE CHAIRMAN reported that he had discussed the question of standardization of gas percentage delivery and percentage dial setting in anaesthetic gas machines with Dr. C. A. Morrell and Dr. J. Katzman of the Department of National Health and Welfare. It had been pointed out to him that standardization of gas machines would be of concern to the medical profession as well as to the dental profession. As a result of his conversations he thought the Committee's purpose would be served if copies of the reports on this subject were made available to the Department of National Health and Welfare for study. He thought the necessary action would be taken if this were done.

It was MOVED by Dr. Thomson and SECONDED by Dr. Charron:

That the reports presented to the Committee on the investigation of anaesthetic gas machines (App. B, 5th Mtg. and App. C, 6th Mtg.) be forwarded to Dr. C. A. Morrell, Director Food and Drugs Division, without recommendation as to action. CARRIED.

(ii) Membership of the Committee

THE CHAIRMAN reported that the Committee had suffered a severe loss in the passing of Dr. E. F. Burton whose advice had always been very helpful in planning Committee activities. He pointed out that Dr. Burton had been put on the Committee as a physicist and he asked for suggestions as to a possible nominee in succession to Dr. Burton. It was felt that owing to the limited membership of the Committee it might be desirable not to restrict the selection of a successor to the one field of science but to give consideration to other branches of scientific work in their relation to dentistry. After some discussion,

It was MOVED by Dr. Thomson and SECONDED by Dr. Charron:

That Dr. A. W. Ham, Professor of Anatomy in charge of histology, University of Toronto, be recommended for appointment to complete the unexpired portion of Dr. E. F. Burton's term of office on the Committee. CARRIED.

4. Publication of Papers

(i) Paper on Denture Base Material

THE SECRETARY reported that a paper entitled "An Improved method for processing acrylic dentures" by D. R. Christie covering work done under grant DR 5 had been published in the Journal of the Canadian Dental Association June 1948 and that reprints would be distributed with the proceedings of the 8th Meeting of the Committee.

(ii) Phosphatase in Saliva

The Publications Committee recommends that permission be granted to Messrs. J. T. Dentay and J.J. Rae for the publication of their paper on "Phosphatase in Saliva". REPORT APPROVED.

(iii) The Therapeutic Properties of Periodontal Cement Packs

The Publications Committee also recommended that permission be granted to Messrs. W.J. Linghorne and

D. C. O'Connell for the publication of their paper entitled "The Therapeutic Properties of Periodontal Cement Packs".

REPORT APPROVED.

(iv) Numbering of Papers

After a brief discussion it was recommended that all papers arising out of work done under Committee grants should be numbered in series and authors should be requested to have the following notation printed in 8-point italic type as a footnote on the first page of the paper:" Contribution from the (here name the laboratory where the work was done) with financial assistance from the National Research Council of Canada. Issued as Paper No. ..... of the Associate Committee on Dental Research. "

In addition, when covers are provided for the reprints, the following notation shall appear thereon:

(i) at the top: National Research Council of Canada.

(ii) in middle of page: Title and author

5. Grantee under Project DR 22

THE CHAIRMAN submitted a letter from Dr. H. K. Box in which he asked to be relieved of the granteeship of project DR 22. Dr. Box pointed out that the problems concerned in this project are very complex and the whole study needs close supervision. He regretted that because of the rapid expansion of his own current investigations he had no time available for the direction of this project.

THE CHAIRMAN explained that the work was being done in the Department of Physiology and he suggested that Dr. C.H. Best be invited to accept direction of the project in view of the fact that this project is being carried on in the Banting and Best Department of Medical Research. RECOMMENDATION APPROVED.

6. New Applications

(i) Employment of Mr. Dentay under DR 1

The Secretary read a letter from Dr. J.J. Rae in which it was stated that Mr. Dentay has transferred from the Physiology and Biochemistry course to the Pass Arts Course and again finds himself with three half days a week free and is most anxious to continue the work on amylase and related subjects on which he was previously employed.

Dr. Rae recommended that a grant of $125. be provided to permit the employment of Mr. Dentay from November to March inclusive at $25. per month. GRANT RECOMMENDED $125.

(ii) DR 24 - Dr. C. H. M. Williams
Associate Professor of Periodontology,
University of Toronto.

"The effects of hard and soft diets on the supporting structures of the teeth. $1420.

THE CHAIRMAN presented the application and outlined the proposed research. After some discussion,

It was MOVED by Dr. Charron and SECONDED by Col. Wansbrough:

That the application of Dr. Williams be APPROVED for the period November 1948 - March 1949 in the amount of $1420. CARRIED.

7. Air Travel

THE SECRETARY reported that Mr. E. R. Birchard, Vice-President in charge of Administration, had expressed the opinion that the Associate Committee on Dental Research should come forward with their recommendation regarding air travel for members prior to asking President's approval for such air travel. He said that permission to travel by air to attend the present meeting had been granted to Dr. R.H. McDougall of Victoria and Dr. H. R. McLean of Edmonton subject to confirmation at this meeting.

It was MOVED by Col. Wansbrough and SECONDED by Dr. Charron:

That the Committee recommends that permission to travel by air be granted for the current fiscal year to Dr. McDougall and Dr. McLean. CARRIED.

8. Budget, 1949-50

THE SECRETARY reported that pending the present meeting he had submitted the following tentative estimates of the financial requirements of the Committee to the National Research Council:

		1949-50	1948-49
1.	Grants-in-aid	$27,500.	$27,500.
2.	Fellowships	5,000.	5,000.
3.	Travel	2,500.	2,500.
4.	Contingencies	500.	500.
		$35,500.	$35,500.

RECOMMENDED.

9. Notification to Grantees

THE CHAIRMAN suggested and it was AGREED that a communication should be sent early in January 1949 to all grantees reminding them that applications for grants for 1949-50 should be in the hands of the Secretary by 1 February, 1949, and that as it was expected the Committee would receive more applications than it could approve it would be necessary to enforce the rule regarding the early filing of applications.

The Meeting adjourned at 12:30.

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NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS

OF THE

EIGHTH MEETING

OF THE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

OTTAWA

26 OCTOBER, 1948

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Appendix "E" An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry by O.J. Walker and H. R. MacLean.

Appendix "F" In vivo studies of certain fungus-like micro-organisms found in periodontal disease by C. H. Best.

Appendix "G" An investigation of the mechanism of repair of the supporting tissues of the teeth by H. K. Box.

Appendix "H" Nitrogen containing compounds in saliva (Sect. 1) by J. J. Rae.

Appendix "I" A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario by M. Doreen Smith.

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Appendix "H" Nitrogen containing compounds in milk. (Beath, D) by J. J. Mac.

Appendix "G" An investigation of the mechanism of repair of the supporting tissues of the teeth by H. K. Box.

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Appendix "C" Tissue toxicity and potency of local anaesthetics by E. A. Sellers.

C. E. Macdonald.

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Appendix "J" Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries, by M. Doreen Smith.

Appendix "K" A study of the use of periodontal packing materials in the prevention and treatment of diseases of the supporting tissues of the teeth by H. K. Box.

Appendix "L" An anatomical, histological and physiological study of the role of the condyle in mastication, by R. J. Godfrey.

Appendix "M" A study of alveolar O_2 tension and blood oxygen content during N_2O anaesthesia by G. H. Lucas.

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Appendix "L" An anatomical, histological and physiological study of the role of the condyle in mastication, by R. J. Godfrey.

Appendix "M" A study of alveolar Op tension and blood oxygen content during H2O anaesthesia by G. H. Lucas.

Appendix "N" Entry of phosphate and carbonate salts into teeth as shown with the help of radio-phosphorus and radio carbon by O.J.Jackson.

Appendix "O" Improvement of subgingival curettage and surgical techniques used in the treatment of periodontal pockets by John Theobald.

Appendix "P" Experimental artificial production of dental caries in vitro by G. J. Box.

Appendix "Q" A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of the dental arches by Norma Ford Baker.

Appendix "R" An improved method for processing acrylic dentures by D. J. Gerrish.

Appendix "S" To study the effects of electrode polarities and deceleration on oral tissues, by the R.C.D.S.

Initial Distribution.

NATIONAL RESEARCH COUNCIL

Proceedings

of the

EIGHTH MEETING

of the

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in Council Chamber, National Research Building
9:30 a.m., 26 October, 1948.

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1. Attendance

Dr. R. G. Ellis, Chairman
Dr. H. K. Brown
Dr. E. Charron
Dr. D. S. Coons
Dr. M. H. Garvin
Dr. H. R. MacLean
Dr. R. H. McDougall
Dr. J. J. Rae
Dr. C. B. Stewart
Dr. D. L. Thomson
Col. E. M. Wansbrough

Mr. S. J. Cook, Secretary

By Invitation

Dr. G. H. W. Lucas
Dr. G. M. MacDonald
Dr. C. H. Moses
Dr. H. H. Saunderson

Mr. S. P. Eagleson (Part of the Meeting)

Apologies for their absence were received from Dr. H. K. Box, Dr. J. B. Collip and Dr. O. W. Ellis.

2. Chairman's Remarks

THE CHAIRMAN welcomed Dr. Stewart who was attending his first meeting of the Committee in succession to Dr. Mainland; Dr. McDougall who has been appointed to complete the unexpired portion of Dr. Stibbs' term as member of the Committee; and Mr. Eagleson, General-Secretary. He was also glad to report

that Dr. E. Charron, Dr. O. W. Ellis and Dr. J.K.W. Ferguson had been reappointed as members of the Committee for a further term of three years to 31 March, 1951. He also welcomed Dr. Lucas, Dr. MacDonald and Dr. Moses who had been invited to attend this Meeting to present reports on the projects on which they are engaged.

3. Minutes of the 7th Meeting

It was MOVED by Dr. Coons and SECONDED by Col. Wansbrough:

> That the Minutes of the Seventh Meeting of the Committee, having been circulated, be taken as read and approved. CARRIED.

4. Minutes of the Fifth Executive

THE CHAIRMAN said that a meeting of the Executive had been held on the preceding day and action had been taken on several matters which had been referred to the Executive by the Committee. He asked the Secretary to read the Minutes of the 5th Meeting. This was done and copies of the Minutes will be distributed as usual to all members of the Committee.

It was MOVED by Dr. Thomson and SECONDED by Col. Wansbrough:

> That the Minutes of the Fifth Meeting of the Executive as read by the Secretary be approved. CARRIED.

5. Discussion Arising Out of the Executive Minutes

(i) Employment of Mr. Dentay under DR 1 (Min.6,(i), 5th Exec.)

DR. RAE said that he had recently learned that Mr. Dentay would be able to devote an additional half-day a week to the work on amylase and he would like therefore to request permission to pay Mr. Dentay $30. a month instead of $25. a month as specified in his letter which would mean $150. for the five months.

It was MOVED by Dr. Rae and SECONDED by Dr. McLean:

> That an additional grant of $150. instead of $125. be provided under DR 1 to permit the part-time employment of Mr. J. T. Dentay at $30. per month, November 1948 to March 1949. CARRIED.

(ii) Air Travel (Min. 7, 5th Exec.)

THE CHAIRMAN referred to the action taken by the Executive in approving air travel for certain members of the Committee who had asked permission to use this means in attending the meetings. He inquired whether any other members would wish to be provided for in the same way. In the following discussion it was found that Dr. Garvin and Dr. Stewart both considered that it would be to their advantage to have authority to travel by air to the February 1949 meeting of the Committee.

It was MOVED by Dr. Coons and SECONDED by Dr. Rae:

That the Committee recommends that permission to travel by air be granted for the current fiscal year to Dr. Garvin, and Dr. Stewart (in addition to Dr. McDougall and Dr. MacLean). CARRIED.

(iii) Budget 1949-50 (Min. 8, 5th Exec.)

THE CHAIRMAN said that it had been necessary to submit a tentative budget for 1949-50 prior to this meeting of the Committee and that the Executive had recommended the submission of the following estimates:

	1949-50	1948-49
1. Grants-in-aid	$27,500.	$27,500.
2. Fellowships	5,000.	5,000.
3. Travel	2,500.	2,500.
4. Contingencies	500.	500.
	$35,500.	$35,500.

RECOMMENDATION APPROVED.

6. Business Arising Out of the Minutes of the 7th Meeting

(i) Fellowships (Min. 29, 7th Mtg.)

THE CHAIRMAN reported that in response to his letter to the National Research Council recommending the establishment of dental fellowships, he had been advised by Mr. S. P. Eagleson, General Secretary, to prepare and submit draft regulations for the government of such fellowships. He had accordingly prepared recommendations and sent them forward to the Council. He had been advised that the recommendation of the Committee regarding dental fellowships had been considered by the National Research Council and referred to its Standing Committee on Scholarships for consideration and recommendation. The next meeting of the Scholarships Committee will be held just prior to the meeting of the National Research Council about mid-December and it was expected that a final decision with respect to the authorization of fellowship awards would be reached at that time. In that event it

would be possible to advertise these fellowships in January 1949 which is the usual time at which announcements are distributed regarding scholarship awards available from the National Research Council.

(ii) Recommendations for Membership (Min.31,7th Mtg.)

THE CHAIRMAN reported that as noted in his opening remarks three members of the Committee had been reappointed for a further term of three years (Dr. E. Charron, Dr. O.W. Ellis and Dr. J.K.W. Ferguson) and that Dr. C.B. Stewart and Dr. R. H. McDougall had been appointed in succession to Dr. Mainland and Dr. Stibbs respectively.

He also regretted to announce that the Committee had suffered a severe loss in the passing of Dr. E. F. Burton and said that the Executive had recommended the appointment of Dr. A. W. Ham, Professor of Anatomy in charge of histology at the University of Toronto, for appointment to complete the unexpired portion of Dr. E.F. Burton's term of office on the Committee. RECOMMENDATION APPROVED.

Reports of Grantees

7. DR 1 - Dr. J. J. Rae

"An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides"

DR. RAE presented his report in three parts (i) nitrogen containing compounds in saliva by C. T. Clegg; (ii) salivary amylase and dental caries by J. T. Dentay; and (iii) interim report No. 6 on the project. These three documents appear in full in APPENDIX "H"

DR. MOSES said he could not see why saliva was treated as a whole since its constituents come from several different glands each of which yields specific secretions, some acid, some alkaline. He thought the secretions should be separated and studied individually.

DR. RAE said that the problem was not simple and that in addition to the difficulty of obtaining suitable quantities of the individual secretions, it had to be remembered that it is in a mixed saliva condition that dental caries occurs. It had been found that there was no phosphatase in clear centrifuged saliva.

DR. THOMSON suggested that it might be interesting to discharge small quantities of non-toxic dyes at the opening of

each gland in the mouth to determine the distribution of secretions from the various glands. Perhaps some technician could undertake this task.

DR. STEWART wanted to know what were the standards for sorting caries susceptible persons from caries immune persons.

DR. RAE said that selection was based on l.b.a. determinations and the dentist's advice. Separation was made on the basis of the extremes (approximately 10% at each end) noted in these results.

THE CHAIRMAN added that the problem was complicated by the fact that persons who were in one category at one time might move to another category at a later time. He said he thought it might be useful to bring half a dozen experts on saliva together for a session at a subsequent meeting of the Committee for a Conference. Names that occurred to him were Kesel, Fosdick, Krasnow, etc.

8. DR 2 - Dr. G. H. W. Lucas

"A study of alveolar O_2 tension and blood oxygen content during N_2O anaesthesia"

DR. LUCAS presented a summary of the work done under this project which appears in full in APPENDIX "M"

He said this work had grown out of a study of the water content of nitrous oxide gas used for anaesthesia on which there had been no figures in the literature. At the present time Dr. Ferguson had expressed his willingness to co-operate in this study using an oximeter to determine the percentage of oxygen content in the blood. He said that difficulty had been found in obtaining satisfactory gas collectors and that he thought also Dr. Tickle would have to develop a new method of gas analysis in connection with this investigation. He believed that the only way to find out what actually happens in anaesthesia is to examine a patient under actual operating conditions in an attempt to determine the percentage of oxygen received by the patient. He said that Dr. Tickle was keenly interested in this problem, was well trained and is doing a good job. He thought it might be necessary later to apply for some additional funds for the purchase of needed additional equipment if the Committee thought this project was worthwhile continuing.

DR. CHARRON said he was very much pleased with the simple, clear explanation made by Dr. Lucas. He thought this project covered a vital problem and should be supported and continued.

THE CHAIRMAN thanked Dr. Lucas for the very frank statement he had made regarding the difficulty of getting patients. He said that the first two phases of this project had been carried forward in a very satisfactory way and important results had been achieved. Now it appeared that a new source of patients had been secured and with the new technique it appeared that very useful results might be secured. He assured Dr. Lucas that he had the full support of the Committee and that everyone appreciated the work that was being done.

It was MOVED by Dr. Thomson and SECONDED by Dr. McDougall:

That this Committee empowers the Executive to make an additional grant up to $500. this year if and when a further application for financial support of this investigation is received. CARRIED.

9. DR 3 - Dr. H. K. Box

"A study of micro organisms found in deep periodontal pockets and caries lesion as revealed by the electron microscope"

DR. BOX in a letter dated 23 October, 1948, wrote as follows: " In regard to project DR 3, I have nothing further to report at the present time. However, I expect to undertake some further studies with the electron microscope very shortly. These, in the main, will relate to my work on the presence of micro organisms in the tissues in periodontal disease. This work has been advancing rapidly in the recent months".

10. DR 4 - Dr. H. K. Box

"A study on the use of periodontal cement packs in the prevention and treatment of disease of the supporting tissues of the teeth"

THE CHAIRMAN said that the final report on this project had been received from Dr. Box and was being included in these proceedings as APPENDIX "K"

A paper based on this work had also been prepared by Dr. W. J. Linghorne and Mr. D. C. O'Connell under the title "The therapeutic properties of periodontal cement packs". This paper had been reviewed by the Publications Committee and accepted for publication by the Executive (Min. 4,(iii), 5th Exec.).

11. DR 5 - Dr. A. E. R. Westman

"Research on denture base materials and denture preparations"

THE CHAIRMAN reported that the paper referred to in Min. 5 7th Mtg. entitled "An improved method for processing acrylic dentures" has now been published and a reprint appears in APPENDIX "R"

12. DR 6 - Col. E. M. Wansbrough

"To study the effects of altitude acceleration and deceleration on oral tissues"

COL. WANSBROUGH presented an interim report on this subject which appears in APPENDIX "S"

13. DR 7 - Dr. J. S. Bagnall

"Investigation and critical report on dental caries research"

THE CHAIRMAN reported that he had heard from Dr. Bagnall to the effect that steady but slow progress is being made on the bibliography and that Dr. Bagnall hopes to have it well in hand for the Spring meeting. He said that members realized that the task undertaken by Dr. Bagnall was a very large one but the subject was important and everyone was looking forward to the publication of the bibliography as it would be a most useful reference.

14. DR 8 -

THE CHAIRMAN said that this project had been completed. Members would recall that it related to "A study of the D.M.F. caries rate of the children of Brantford prior to the addition of fluorine to the water supply".

On completion of this investigation the Committee had suggested that this work be taken over by the Department of National Health and Welfare since it involved surveys and surveys were not considered as coming within the research field by the National Research Council. He reminded the members that a resolution had been passed (Min. 5(ix), 4th Mtg.) recommending that dental research surveys should be carried out and authorizing the Executive to co-operate with the Division of Dental Health of the Department of National Health and Welfare in working a satisfactory programme of investigation on this subject.

11. DR 5 - Dr. A. E. E. Westman

"Research on denture base materials and denture preparations"

THE CHAIRMAN reported that the paper referred to in Min.5 7th Mtg. entitled "An improved method for processing acrylic dentures" has now been published and a reprint appears in APPENDIX "E"

12. DR 6 - Col. E. M. Wansbrough

"To study the effects of altitude acceleration and deceleration on oral tissues"

COL. WANSBROUGH presented an interim report on this subject which appears in APPENDIX "F"

13. DR 7 - Dr. J. S. Bagnall

"Investigation and critical report on dental caries research"

THE CHAIRMAN reported that he had heard from Dr. Bagnall to the effect that already but slow progress is being made on the bibliography and that Dr. Bagnall hopes to have it well in hand for the Spring meeting. He said that members realized that the task undertaken by Dr. Bagnall was a very large one, but the subject was important and everyone was looking forward to the publication of the bibliography as it would be a most useful reference.

14. DR 8 -

THE CHAIRMAN said that this project had been completed. Members would recall that it related to "A study of the D.M.F. caries rate of the children of Brantford prior to the addition of fluorine to the water supply".

On completion of this investigation the Committee had suggested that this work be taken over by the Department of National Health and Welfare since it involved surveys and surveys were not considered as coming within the research field by the National Research Council. It remained the members that a resolution had been passed (Min. 5(ix), 4th Mtg.) recommending that dental research surveys should be carried out and authorizing the Executive to co-operate with the Division of Dental Health of the Department of National Health and Welfare in working a satisfactory programme of investigation on this subject.

DR. BROWN said that the programme of work sponsored by his Department was proceeding satisfactorily. Examination had been made of 1800 children at Brantford and the sampling had been arranged by the research department with the aid of statistical advice from the Dominion Bureau of Statistics. He had obtained the co-operation of Sarnia also for control purposes as the fluorine content of the water in Sarnia is insignificant. Examinations are also proceeding in Stratford where the drinking water contains the optimum amount of fluorine. The investigation will be extended over a period of seven years. In Stratford it is expected that 800 children will be examined by Christmas. The water supply in Stratford contains 1.3-1.6 p.p.m. sodium fluoride and the source of supply has been the same for thirty years. He proposes to examine only children born in a given area and who have never been absent for more than six weeks at any one time from that area. He reminded the Committee that fluorine had been added to the Brantford water supply continuously since June 1945. His idea was that examination of the children needs only to be repeated every third year but he invited the Committee's advice on this subject.

DR. RAE inquired regarding the distribution of fluorine in Brantford water and how often analyses were made.

DR. BROWN said that samples were taken daily from various parts of the system. Analyses ranged from 0.9 to 1.2 p.p.m. with an average of 1.1 for thirty consecutive readings. The procedure in adding fluorine to the water is the same as that used in the United States for adding vitamins to flour.

THE CHAIRMAN thought that it might be useful to conduct the survey on an annual basis in Brantford with check examinations in Stratford and Sarnia every third year. Then if discrepancies occurred the annual figures for Brantford would show whether the progress there had been continuous. In conclusion he thanked Dr. Brown for having initiated this survey work which he was sure would produce results of great interest and value.

15. DR 9 - Drs. O. J. Walker and H. R. MacLean

"An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry"

DR. MACLEAN presented a summary and report on the work which appears in full in APPENDIX "E"

DR. THOMSON suggested that since bicarbonates are unstable it might be of interest to analyse the materials towards the end of the test to determine whether the strength of the several ingredients has been maintained.

DR. MACLEAN said that it was now proposed to limit work to one solution at a time and to the use of one metal.

DR. BROWN was concerned about the aim of the research. He thought that if solutions that were injurious were being marketed the Food and Drugs Division of his Department ought to take action.

THE CHAIRMAN pointed out that the solutions under investigation are not used normally as mouth washes but that people deposit dentures in them overnight and that extensive corrosion often takes place during this long period of immersion. He suggested that the present investigation was intended to uncover the facts of the situation and that if the Committee could obtain well substantiated evidence as to the harmfulness of solutions on the market, the procedure would be to send a report on the Committee findings to the appropriate authorities such as the Department of National Health and Welfare. This was the plan that had been followed in the investigation of gas delivery apparatus.

16. DR 10 - Dr. G. M. MacDonald

"Facial prostheses of vinyl resins"

DR. MACDONALD presented his report which appears in full in APPENDIX "B"

17. DR 11 - Dr. R. J. Godfrey

"An anatomical, histological and physiological study of the role of the condyle in mastication"

DR. MOSES presented a summary and report which appear in APPENDIX "L" He said that he concurred in the view that the work should be restricted but in explanation of the variety of work undertaken he pointed out that most of these different jobs were short-term investigations that could be carried on in spare time without detracting from the main project. He suggested that the title of the project should be changed to read as follows: "An anatomical, histological and physiological study of the temporo-mandibular joint". The Committee AGREED.

18. DR 12 - Dr. A. E. R. Westman

"Investigation of cements for methacrylate inlays"

A summary and a report No. 4801 on this subject were presented and are published in APPENDIX "D"

19. DR 13 - Dr. M. Doreen Smith

"A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario"

A summary report on this subject appears in APPENDIX "I"

DR. RAE inquired whether the grantee had tried other methods of analysis.

DR. GARVIN said that he would like to see work done to check the results reported by Gottlieb who had claimed that the reduction in caries through the topical use of fluorine was 37%, but Gottlieb claimed a reduction of 90% using zinc chloride and potassium ferrocyanide in a paper published recently in the Journal of the Canadian Dental Association.

20. DR 14 - Dr. M. Doreen Smith

"Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries"

A summary of the work under this project appears in APPENDIX "J"

DR. McDOUGALL expressed the opinion that a child's liquid diet consists of approximately 60% milk and 40% water and he thought that with the indicated low fluorine content of milk in the Stratford area the results of the investigation might be misleading.

DR. BROWN pointed out that all the cooking of vegetables and meats is done in water and that the fluorine content of the water is absorbed to some extent by these products so that consumers may actually receive substantial amounts of fluorine even though the water content of fluorine is relatively low.

DR. RAE said it would be important to know whether the fluorine was present as calcium or sodium fluoride. He promised to communicate with Dr. Smith in this connection.

21. DR 15- Dr. Norma Ford Walker

"A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of the dental arches"

A summary of the work on this project appears in APPENDIX "Q"

22. DR 16 - Dr. C. H. Best

"In vivo studies of certain fungus-like micro organisms found in periodontal disease"

A summary of the work on this project appears in APPENDIX "F"

DR. MOSES referring to the concluding paragraph of this report to the effect that the grantees have been unable to cultivate the leptothrix falciformis in artificial media, said that he was under the impression that he had seen examples at Toronto of artificial cultures of this organism.

23. DR 17 - Dr. R. F. Shaner

"An investigation of the effects of solutions used in operative dentistry on the vital pulps of teeth"

DR. MACLEAN explained that the assistant who had been engaged on this project had first studied mathematics and statistics and had then taken up dentistry. As a result he had found it necessary to concentrate on dental work in his final year and had only been able to review the literature in connection with this project. The work had lapsed when he graduated. He is now practicing dentistry two hundred miles from Edmonton and it is not feasible to have him proceed with this investigation. The project is worthwhile but it will be necessary to find a suitable assistant and when this has been done a further application for a grant-in-aid will be made.

24. DR 18 - Dr. H. K. Box

"The experimental artificial production of dental caries in vitro"

A report on this investigation appears in APPENDIX "P"

THE CHAIRMAN said that he would invite Dr. Hugill to come to the next meeting to discuss this project.

DR. RAE thought pepsin was not dominant in saliva and suggested that amylase is a much more characteristic enzyme in saliva. He wondered why the investigators did not use sucrose and lacto-bacillus to simulate mouth conditions. Also he did not understand what was meant by the terms "20%, 30% and 40% pepsin enzyme activity".

25. DR 19 - Dr. E. A. Sellers

"Tissue toxicity and potency of local anaesthetics for topical application and nerve block in dentistry"

A summary of the work on this project appears in APPENDIX "C"

DR. LUCAS said that Dr. Aikenhead was now giving his full research time to this project and the work was proceeding satisfactorily on animals. He thought it would be advantageous, as suggested in Dr. Ferguson's concluding sentence in the report, if a dental graduate could be obtained to continue these studies by a dental technique and particularly if the work could be done on humans.

26. DR 20 - Dr. Jules Thébaud

"Improvement of subgingival curettage and surgical techniques used in the treatment of periodontal pockets "

The report on this subject appears in full in APPENDIX "O"

DR. CHARRON brought to the meeting a collection of prototypes of instruments developed by Dr. Thébaud which he passed around for inspection. He expressed regret that Dr. Box was not present at the meeting since this subject is one on which he is so well informed. He thought it would be helpful if arrangements could be made to have both Dr. Box and Dr. Thébaud present at the next meeting of the Committee in order that the members might have the benefit of hearing the discussion between these two experts in this field as to the merit and usefulness of these proposals.

27. DR 21 - Dr. A. E. R. Westman

"Investigation of repair technique for methacrylate dentures"

A summary of the work on this project and progress report numbers 4802, 4803, 4804, 4805, 4806, 4807 appear in APPENDIX "A"

THE CHAIRMAN said that this work was proceeding very satisfactorily and he thought it would be possible to have a final report on it at the next meeting of the Committee.

28. DR 22 - Dr. H. K. Box

"An investigation of the mechanism of repair of the supporting tissues of the teeth"

An interim report on this subject appears in APPENDIX "G"

THE CHAIRMAN said that it would be noted the work was described under six phases and it had been the view of the Committee that the investigation should be directed into more specific channels. Dr. Linghorne had reported recently to the Chairman that Dr. Best proposed that he (Dr. Linghorne) concentrate work on phases 1 and 2 and that the report on this project to be presented at the next meeting would deal with these two sections of the investigation.

29. DR 23 - Dr. C. P. Leblond

"Entry of phosphate and carbonate salts into teeth as shown with the help of radio-phosphorus and radio-carbon"

A summary of the work appears in APPENDIX "N"

DR. RAE inquired whether it would be possible to obtain radioactive fluorine and carry out experiments to determine whether the fluorine comes in through the dentine or topically on the enamel surface.

DR. SAUNDERSON suggested that inquiry be made of Dr.G.H.Guest at the Atomic Energy Project, Chalk River, as to whether radioactive fluorine was available.

This concluded the presentation of reports. The Chairman said that he thought at the next meeting it might be desirable to start with the newer projects and work back in order that more emphasis might be given to the work on the newer investigations. He thought also it would be necessary to plan for a two-day meeting in February in order that adequate consideration might be given to the reports from the grantees. He proposed also to continue the practice followed in meetings thus far of having at least three grantees present to report in person on their projects.

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30. Publication of Papers

THE CHAIRMAN said that at the first meeting of the Associate Committee on Dental Research (Min. 6) it had been agreed that all papers based on work done under projects supported by the Associate Committee on Dental Research should be reviewed and approved by the Executive in their capacity as the Publications Committee before being published. This procedure sometimes led to delays in handling the manuscripts and in a discussion on this subject at the Executive Meeting

it had been agreed that one member of the Executive should be chosen in each case to be responsible for the review of a given paper and that his written report would then be transmitted to the other members of the Panel for their formal approval. It was thought this procedure would expedite the reviewing of papers.

DR. MCDOUGALL suggested that the Journal of the Canadian Dental Association take note of all papers published on Committee work for the information of its readers.

THE CHAIRMAN said that a leaflet listing all papers published under Committee auspices might be prepared and that it would be helpful if each author were asked to prepare a short review of his paper which could be used for publicity purposes. He thought a 200-word abstract should be requested on each paper.

DR. GARVIN said that he would be glad to include a statement in the Forum section of the Journal of the Canadian Dental Association on papers submitted by the Committee.

It was MOVED by Dr. Thomson and SECONDED by Dr. Stewart:

> That this Committee instructs the Executive in their capacity as the Publications Committee to confer with Dr. Garvin on the most effective means of bringing to the attention of the dental profession information regarding papers published under Committee auspices and projects sponsored by the Committee. CARRIED.

A short discussion ensued in which it was suggested that the work of this Committee might be made known to Dental research organizations in the United States, Great Britain and other countries in the hope that information regarding activities of similar organizations in other countries might be made known to Canadian dentists.

The meeting adjourned at 4:40 p.m.

APPENDIX "A"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October 1948

Subject: Investigation of Repair Technique for Methacrylate Dentures.

Grantee: Dr. A. E. R. Westman

Project: DR 21 Amount of Grant: $5,000 (including DR 12)

SUMMARY OF WORK

Regular monthly progress reports on this project have been submitted to the Associate Committee. Experimental work on this problem has been concerned with the development of suitable repair techniques for methyl methacrylate dentures.

At the time of the last meeting of the Associate Committee, details of a low-temperature repairing or curing technique which would allow repairs to be made without distortion were just being completed. A period of 16 hours at 135°F. is required by this method. In order to obtain a satisfactorily strong plastic under these conditions, it is recommended that inhibitors be removed from commercially-supplied monomers and that a small amount of a catalyst, such as benzoyl peroxide, be added to the monomer just before mixing it with the powder component.

In an effort to reduce the necessary curing time from 16 hours to something nearer to 4 hours the use of ultra-violet light was investigated.

Using about 0.1 per cent benzoin as a light-activated catalyst and the same amount of benzoyl peroxide as a thermal catalyst, methyl methacrylate denture base material can be completely cured in 3-1/2 hours.

The preparation of a denture for a repair is carried out in the usual manner. The new denture base material to be added is made with inhibitor-free monomeric liquid containing the catalysts mentioned above and the usual polymer powder. The curing time consists of a 2-hour period at 135°F., at the end of which the new material is polymerized to a degree which permits the flask to be opened,

and a period of 1-1/2 hours under ultra-violet light, also at 135°F. The irradiation is carried out by immersing that half of the flask containing the denture in a water-bath up to the rim of the flask and with the use of a General Electric UA2-250-watt mercury vapor lamp placed 6 inches from the denture.

Laboratory tests have again shown no distortion in dentures repaired by this ultra-violet method. Suitable tests will be carried out very shortly on a variety of repair problems with the cooperation of the Dental College of the University of Toronto.

In connection with some work which is more properly concerned with Project DR 12, it has been found that the use of trihexylamine, a catalyst mentioned in reports on German laboratory investigations, offers possibilities of making repairs even more quickly that by the use of ultra-violet light. In fact, with a short heat treatment in a water bath, followed by a brief irradiation from an infra-red lamp, experimental dentures have been repaired successfully without distortion in an hour and a half. More details will be available at a later date. However, a final report on repair techniques can be expected in the near future.

Douglas R. Christie

24 September, 1948.

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4802 - DR 21

Scope of this Report

This report deals with actual repairs made on experimental dentures to obtain additional confirmation of the suitability of a low-temperature curing cycle. Permissible temperature variations of this method are reported as well as some experiments on polymerization by ultra-violet irradiation.

Repairs at 135° F.

To date four dentures have been prepared by two methods, conditioned in water and actually repaired by removing teeth and adding new denture base material.

One method of making the dentures was the same as that used at the Dental College of the University of Toronto. The denture was heated at 160° F. for one hour and then at 212° F. for 15 minutes. The denture was allowed to cool slowly in the water-bath. The second method was to heat the denture from room temperature to 212° F. in one hour, at 212° F. for 15 minutes and then to cool by plunging the dental flask in cold running water. The latter method is probably the most severe treatment, from the point of view of internal stresses, which can be used to prepare a denture while the first one should cause a minimum of stress.

Two full upper dentures were made by the first method outlined above and a full lower and full upper by the second method. The dentures were then conditioned in water at room temperature for at least 3 days. An occlusal index was made in stone and a new stone cast made from each denture immediately before repairing. From each of these dentures, any two adjacent teeth were removed and the denture prepared for a repair in the customary manner.

The denture base material to be added was mixed using one part of inhibitor-free monomer with 0.1% benzoyl peroxide and 3 parts of Lucitone polymer powder. Curing was done in a water-bath at 135° F. for 16 hours or over-night.

Results of Repairs

After repairing, the dentures were tried on their respective casts and occlusal indices. A very slight discrepancy in the adaptation to the cast was noted in each case at room temperature. However, if the denture was warmed in water at body temperature (99° F.) and then tried on the cast, a perfect fit resulted. The adaptations to the occlusal indices were excellent in all cases.

It has already been shown that curing methyl methacrylate denture base material for 16 hours at 135° F. produces a polymer which satisfied the requirements of the transverse strength test of the A.D.A. specification No. 12. The absence of distortion in dentures repaired under these same conditions is additional proof that this is a suitable method for effecting repairs.

A few more dentures are now being made and repaired and photographs of repaired dentures, showing their adaptation to casts, have been made but are not ready to be included in this report.

Permissible Temperature Variations

The question has arisen as to what variations in temperature are permissible when the low-temperature repairing method is used. The reason is that, if this method is put into actual practice, the equipment in many dental laboratories may not be capable of controlling the water-bath temperature as accurately as the equipment we have used, i.e., at 135 ± 2° F.

To study this problem, samples of methyl methacrylate were cured at 130° F. for 16 hours and then tested for transverse strength and a denture was repaired at 140° F. for 16 hours and any distortion noted.

The specimens which were cured at 130° F. for 16 hours were satisfactorily strong and comparable to those cured at 135°F. for the same period. The following table shows these results.

Transverse Strength of Methyl Methacrylate

Cured at 130°F. for 16 Hours

Monomer Used	No. of Specimens	Deflection at 4000 gm.	Deflection at 6000 gm.	Average Max. Load
Inhibitor-free	3	2.42	5.63	6700

The denture which was repaired at 140° F. for 16 hours was originally made by the rapid technique described above in this report. When this denture was warmed to 99° F. and applied to its occlusal index, the fit was very good. However, there was a small discrepancy in its adaptation to its cast, showing that a very slight distortion had occurred. This indicates that 140° F. is too high a temperature at which to make repairs safely. The permissible temperature range then seems to be between 129° F. and 137° F. A water-bath for making repairs should then be controlled at 133 ± 4° F. or at 56 ± 2° C.

Ultra-Violet Irradiation

We are still awaiting the delivery of some new ultra-violet equipment but in the meantime are making some experiments with the apparatus on hand.

It seemed desirable to make a study of the penetration of ultra-violet radiations through pink methyl methacrylate denture base material. Experiments have shown that after a preliminary heat treatment at 135° F. for 2 hours and 3 hours' exposure to ultra-violet radiations from an 80-watt mercury vapor tube and at a distance of 6 inches from the tube, a plate of pink denture base material has a Knoop hardness value on the exposed surface comparable to that of material cured at 135° F. for 16 hours, i.e., about 14. However, the unexposed surface of a 1/8-inch plate is still quite soft and obviously incompletely polymerized. Its hardness may be between 5 and 6.

Since the average repair requires the addition of new material about 1/8-inch thick, it would be interesting to determine how the hardness varies through the plastic form the exposed surface to the unexposed surface.

We have made one study of this effect but are not in a position to state at present what the relationship is between hardness and the thickness of the material. Indications are that the hardness may vary inversely as the depth of the ultra-violet penetration.

We plan to continue this investigation and to make others with the use of ultra-violet light in an endeavor to effect the rapid polymerization of methyl methacrylate at low temperatures.

March 5, 1948.

Douglas R. Christie
Research Fellow

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4803 - DR 21

Scope of this Report

This report presents some photographs of dentures repaired by two methods and attempts to illustrate the effects of these methods on the dimensions of the dentures. Some experimental work on the polymerization of methyl methacrylate by ultra-violet radiation is also included.

Photographs of Dentures

In previous reports we have shown that dentures repaired by curing the new material at 135° F. for 16 hours undergo little, if any, dimensional changes and that dentures repaired at 160°F. for about 6 hours can be expected to shrink about one-half of one per cent.

Figures 1, 2 and 3 show dentures repaired by the low-temperature method. It can be seen that the adaptations to the respective stone casts is very good. These dentures were not forced on to the casts but were merely warmed to body temperature (99° F.) and placed lightly on the casts. Figure 4 shows a denture which was repaired at 160° F. for 6 hours. It was also warmed to 99° F. before being placed on the cast. It will be noticed that the adaptation is not as good as in Figures 1, 2 and 3.

It is difficult to show by photographs the fit of a denture to an occlusal index. For this reason, no photographs of this feature were made. However, it was found that dentures repaired at 135° F. for 16 hours showed excellent adaptation to their occlusal indices while dentures repaired at 160° F. for 6 hours would not fit accurately.

We should like to point out that denture base material made with inhibitor-free methyl methacrylate with an added 0.1% of benzoyl peroxide catalyst and the ordinary polymer powder

which is cured at 135° F. for 16 hours is strong enough to pass the American Dental Association transverse strength test. But, as indicated in the dental literature on several occasions, methyl methacrylate denture base material cured at 160° F. for a period of less than 9 hours is not strong enough to meet the transverse strength test specifications.

Use of Duplicator

An apparatus known as the Hooper duplicator which is used in rebase cases to ensure exact duplication of occlusion and vertical dimension, can be used to give a qualitative test of dimensional changes caused by repairing.

The denture to be repaired is mounted in the duplicator on an occlusal index and cast so that the posts on the bottom part of the duplicator are flush with the surfaces on the upper part of the duplicator. If any dimensional changes occur on repairing, the denture will not show perfect adaptation to the index and cast and, consequently, the posts will not fit flush with the top surfaces.

This apparatus was used to compare the effect of repair conditions on two full upper dentures which were made as nearly alike as possible. One was "repaired", without the addition of new material, at 160° F. for 5 hours and the other was heated for 16 hours at 135° F. Figures 5 and 6 show respectively the dentures after repairs at 160° F. and 135° F. mounted on the duplicator.

It is evident that the 160° F. treatment caused a greater dimensional change than did the 135° F. treatment. It should be pointed out that the changes are not quite as great as the duplicator indicates. It may be considered to have a zero error which can not be estimated quantitatively. After removal of the mountings for the index and cast from the duplicator, it was found that they would not fit back on again accurately, even though the plaster or stone was allowed to set in the duplicator for several hours so that virtually all the setting expansion had occurred. The discrepancy which resulted was of the same order of that shown in Figure 6.

Ultra-Violet Polymerization

We have been conducting some experiments on the polymerization of methyl methacrylate by means of ultra-violet irradiation. These experiments have consisted chiefly of

polymerizing small plates of denture base material or inlay material with nominal thicknesses of 4 mm., and then determining the Knoop hardness gradient through the plate from the ultra-violet exposed surface to the unexposed surface.

Several curves showing the results of these investigations are presented with this report. It will be noticed that each polymerization consisted of a preliminary heat treatment of 2 hours in a plaster mold in a water-bath of 135° F. This produces an initial cure which allows the material to be removed from the mold without distortion. In addition an 80-watt mercury vapor lamp placed 6 inches from the samples was used as a source of ultra violet light. The inhibitor-free monomeric constituent of the mix contained in all cases 0.1 per cent of a thermal catalyst, benzoyl peroxide, and 0.1% of a light-activated catalyst, benzoin.

Figure 7 shows the hardness gradients obtained for two samples of methyl methacrylate (Lucitone) pink denture base material. One was irradiated with ultra-violet light for 3¼ hours while the other was irradiated for 4½ hours. The hardness on the exposed surface in the first instance was 16.0 compared with 16.2 for the second. The additional exposure, then produced little difference in the hardness of the exposed surface and 16.2 may be assumed to be very near the maximum obtainable hardness. On the other hand, as was expected, the additional exposure increased the hardness of the material below the surface. It is desirable, of course, to increase the under-surface hardness, by some method, to a figure approaching the maximum obtainable hardness.

Figure 8 shows the gradient produced by 3¼ hours of ultra-violet irradiation on a sample of methyl methacrylate inlay material -- Hue-Lon, Shade 65. Here again the surface hardness approaches the maximum but the under-surface hardness falls off very rapidly until it reaches a steady value which is about 60 per cent of the maximum. This curve suggests that the polymer produced at the surface or the pigments contained in the sample absorb the ultra-violet radiation to a great extent. We believe that the surface polymer is responsible for the absorption in view of the data presented in Figure 9.

Here, one sample of pink Lucitone denture base material and one of inlay material have been irradiated with mercury vapor lamp radiations transmitted through a Corning color filter-- No. 5970. This filter transmits only wave-lengths between 3000 and 4200 A.U. with a maximum transmission at 3650 A.U. The same pigments are present in each sample as were contained in samples discussed in Figures 7 and 8, but the level of polymerization

has been raised throughout the sample. It would seem that the filter has cut out some radiations which produce very rapid polymerization on the surface resulting in an ultra-violet absorbing film. The absence of this surface layer allows the ultra-violet rays to penetrate the sample and produce more uniform polymerization. The difference between the two curves in Figure 9 indicates that the pigment in the pink denture base material absorbs ultra-violet light to a greater extent than does the pigment in the inlay material.

It would be interesting to learn if additional exposure to ultra-violet would shift the curves in Figure 9 to a still higher level and what effects of increased lamp-power and distance of the samples from the lamp would be.

Trihexylamine

We have received a communication from the Wyandotte, Michigan plant of Sharples Chemicals Inc. stating that they have received our request for some trihexylamine but that they had some production difficulties. They hope to be able to send us a sample on or about April 15.

Future Work

1. Continue experiments on the polymerization of methyl methacrylate under ultra-violet light.

2. Investigate the use of trihexylamine as a catalyst for the rapid polymerization of methyl methacrylate.

3. Renew some investigations on the use of hot-melt and other resins for cements for methacrylate inlays.

April 9, 1948.

Douglas R. Christie
Research Fellow.

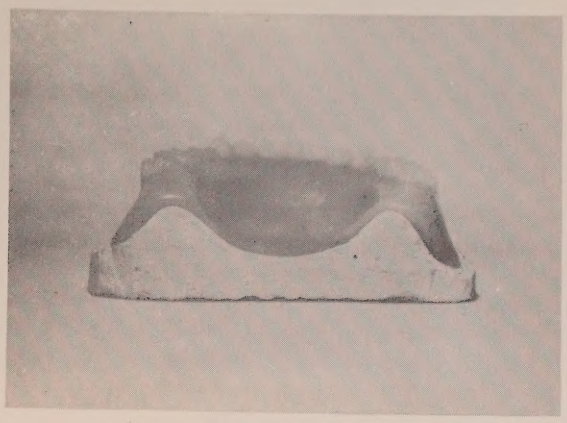


Figure 1.

Figure 2.

Figure 3.

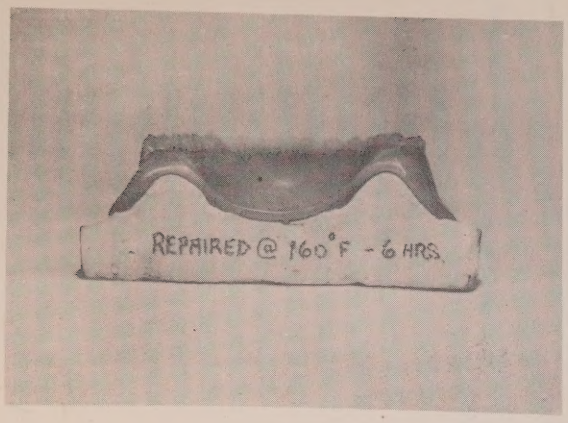


Figure 4.

Figure 5.

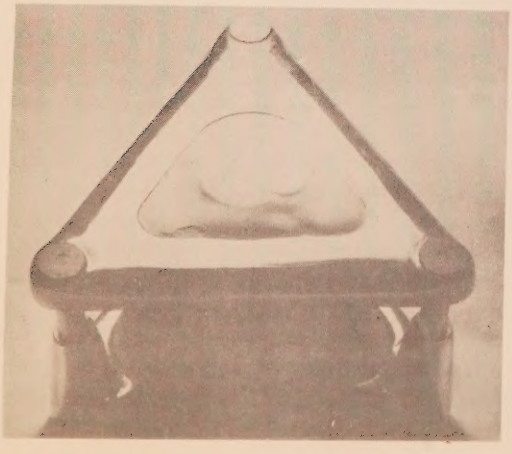


Figure 6.

FIGURE 7

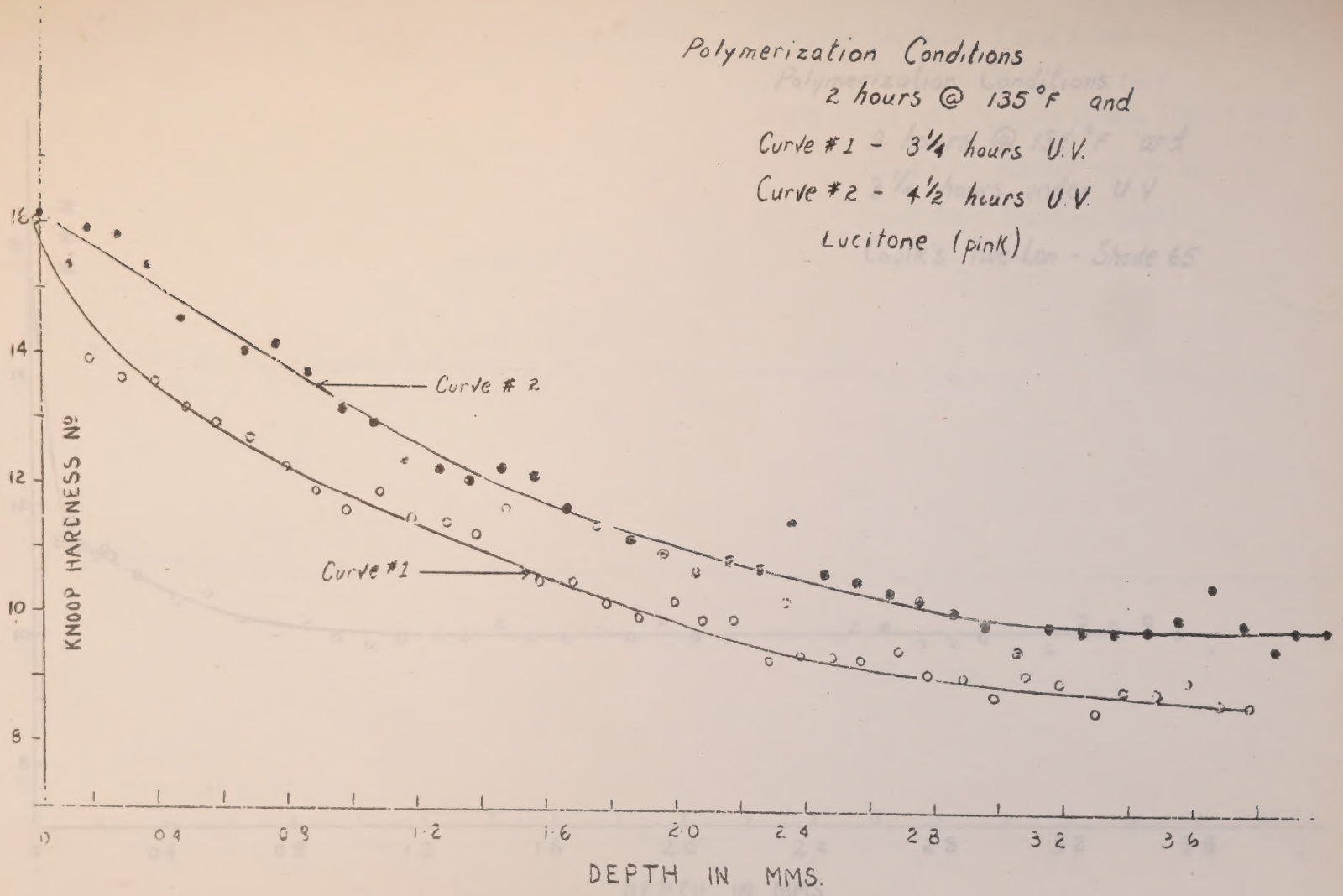


FIGURE 7

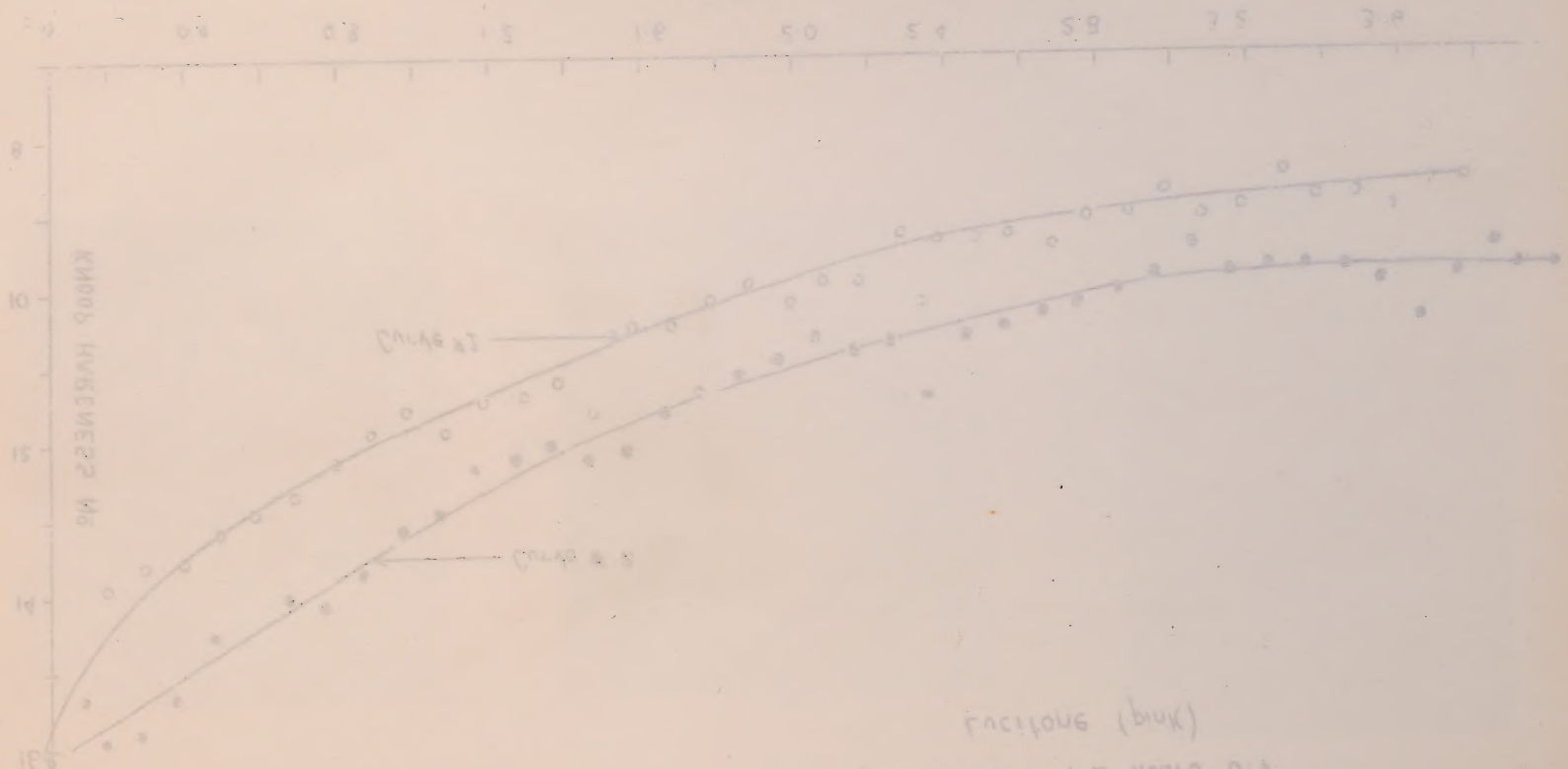


FIGURE 8

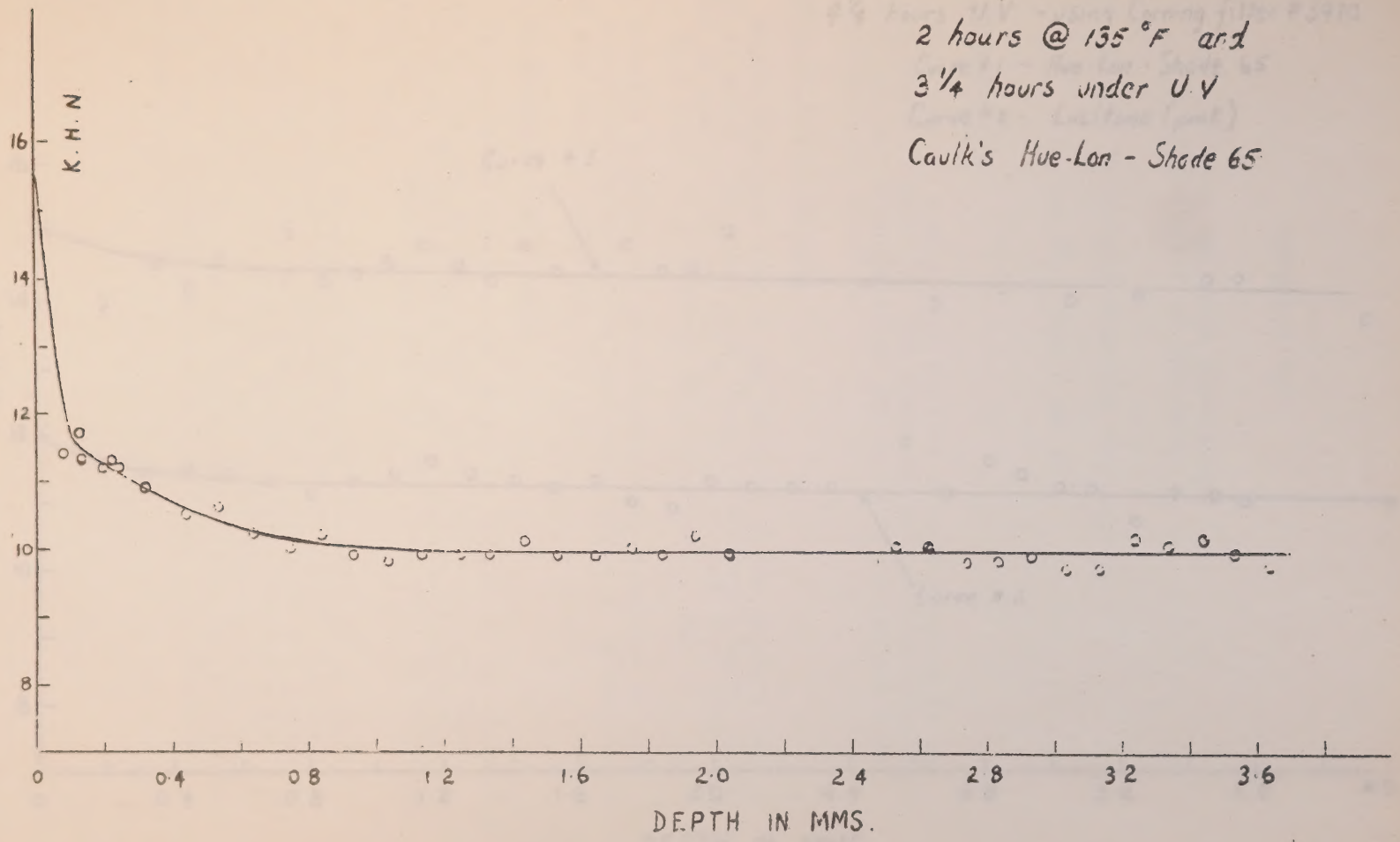


FIGURE 8

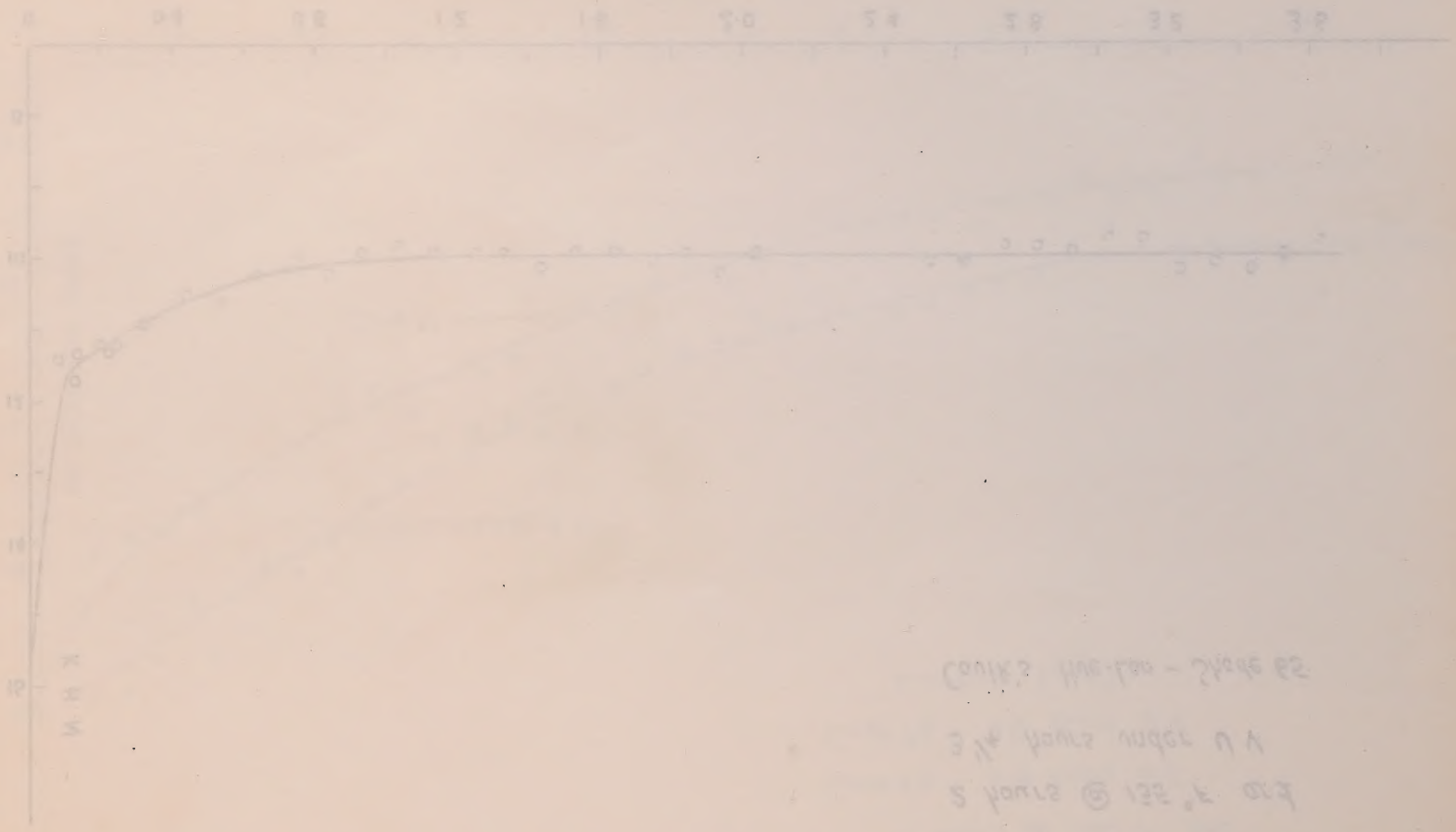


FIGURE 9

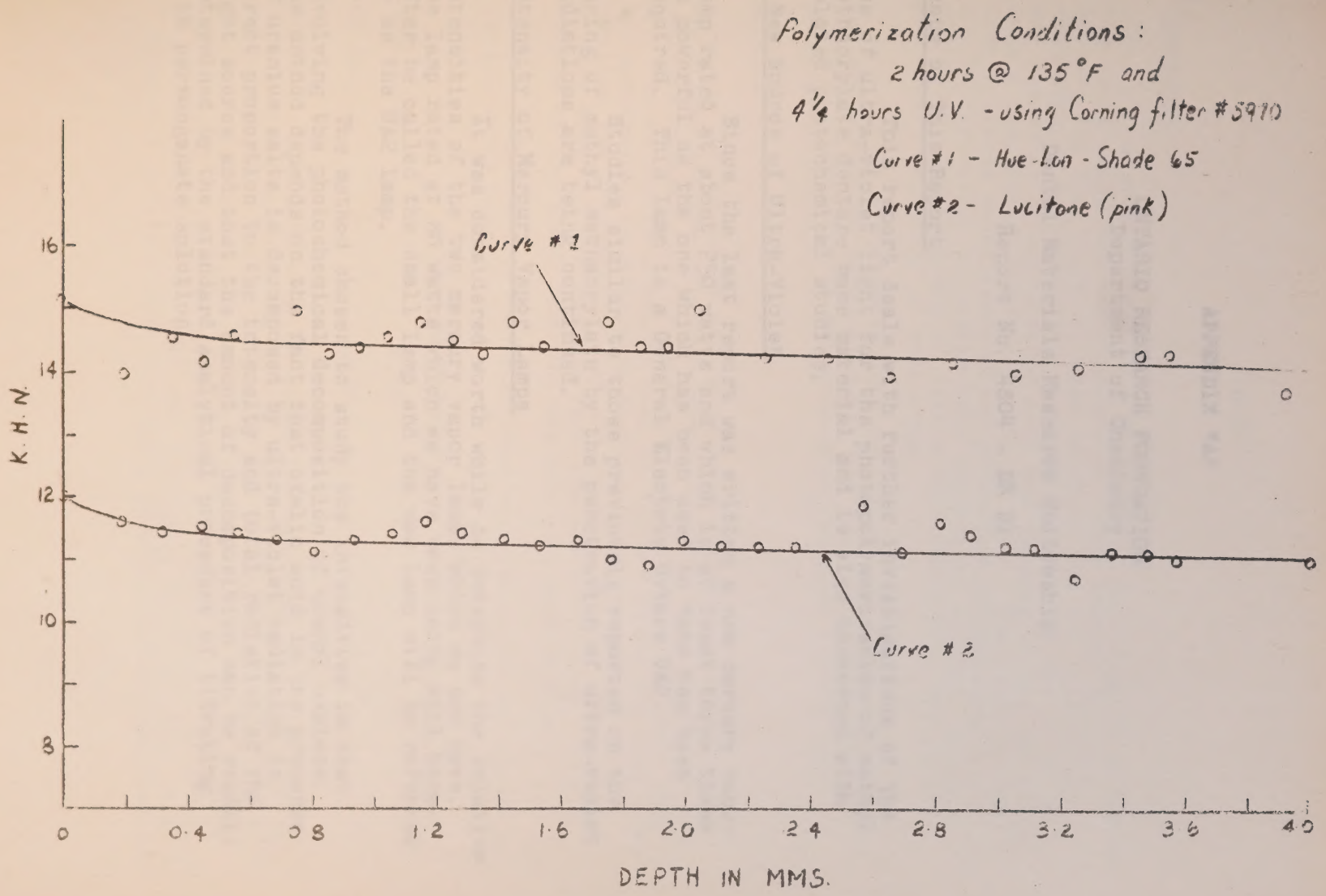
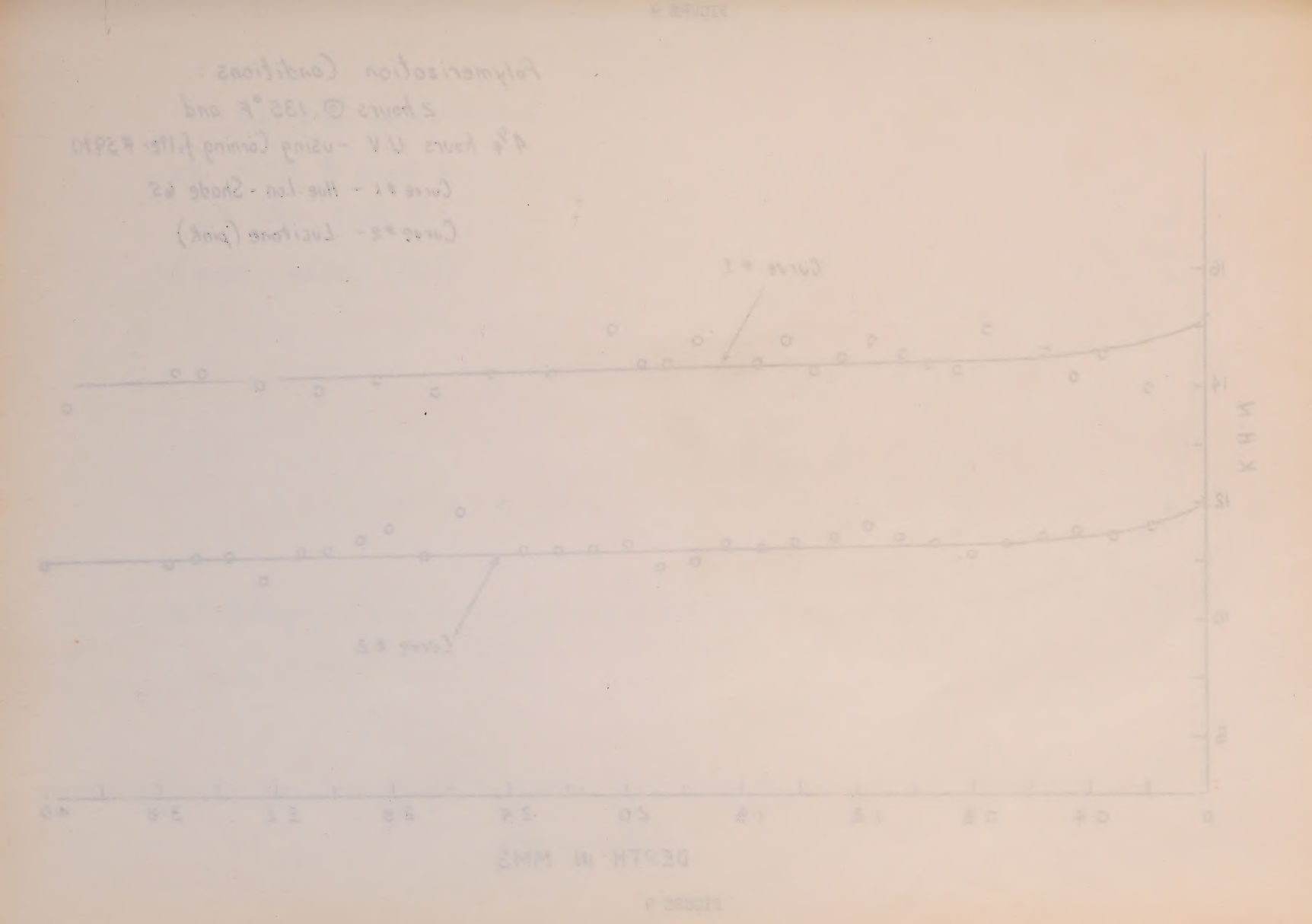


FIGURE 9



APPENDIX "A"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4804 - DR 21

Scope of This Report

This report deals with further investigations of the use of ultra-violet light for the photopolymerization of methyl methacrylate denture base material and is also concerned with related photochemical studies.

A New Source of Ultra-Violet

Since the last report was written a new mercury vapor lamp rated at about 250 watts and which is at least three times as powerful as the one which has been used to date has been acquired. This lamp is a General Electric Uviarc UA2.

Studies similar to those previously reported on the curing of methyl methacrylate by the penetration of ultra-violet radiations are being continued.

Intensity of Mercury Vapor Lamps

It was considered worth while to determine the relative intensities of the two mercury vapor lamps which we now have. The lamp rated at 80 watts which we have been using will hereafter be called the small lamp and the new lamp will be referred to as the UA2 lamp.

The method chosen to study the intensities is that involving the photochemical decomposition of uranyl oxalate. The method depends on the fact that oxalic acid in the presence of uranium salts is decomposed by ultra-violet radiation in direct proportion to the intensity and total radiation of the light source and that the amount of decomposition can be readily determined by the standard analytical procedure of titrating with permanganate solution.

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 6400 - DR 21

Procedure

A standardized (0.1 N) solution was prepared containing oxalic acid and uranyl acetate. (The acetate was used because the more commonly used sulphate was not immediately available.) An accurately measured quantity of the solution was placed in an actinometer cell and exposed to the radiation from a lamp for a definite period of time. The solution was then titrated with standardized potassium permanganate solution, the decomposition of oxalic acid determined and the intensity expressed as milligrams of oxalic acid decomposed per minute per square decimeter of cell area.

The actinometer cell is essentially a glass cylinder, one centimeter in internal depth and about 5 centimeters in internal diameter with two side-arms attached and one face being pyrex glass.

Results

It should be indicated here that the sensitivity of the uranyl oxalate solution varies with the wave-length of the incident radiation - the greatest sensitivity being near 3200 A.U. It is for this reason that the method finds its most useful application in comparing similar light sources or for checking the constancy of any one source. In the experiments we have made, it was assumed that the spectral energy distributions of the small lamp and the UA2 lamp were similar.

The results as determined experimentally are shown in the following table.

	Intensity	
	All Wave-lengths	Through 5970 Filter
Small lamp	0.65	0.19
UA2 lamp	2.50	0.56

The ratio 2.5/0.65 = 3.85 would indicate that the UA2 lamp is about 4 times as powerful as the small lamp when all wave-lengths are considered. The ratio 0.56/0.19 = 2.95 shows that when the radiations are passed through Corning filter 5970 the UA2 lamp is about 3 times as powerful as the small lamp. In addition the ratios 0.65/0.19 = 2.90 and 2.5/0.56 = 4.47 by their lack of agreement indicate that our basic assumption that the spectral

energy distributions of the two lamps are similar is not entirely justified. However, it can be stated that the ability of the UA2 lamp to promote the photopolymerization of methyl methacrylate is roughly three times the ability of the small lamp.

Ultra-Violet Absorption

A brief study was made of the ultra-violet absorption curves for methyl methacrylate. The heat catalyst, benzoyl peroxide and the light-activated catalyst, benzoin in the neutral solvent iso-octane. These curves are shown in Figure 1.

The ability of a photochemical reaction to occur depends on the absorption of light of the appropriate wave-length. The curves in Figure 1 show that the three compounds investigated absorb light in the ultra-violet region of the spectrum. It is safe to assume, then, that reaction will occur principally when ultra-violet light is absorbed. It does not necessarily follow, however, that the extent of the reaction will take place in direct proportion to the absorption because there are many complex factors which determine the efficiency of a photochemical reaction. It is not the purpose of this investigation to discuss or study at length the theory of photochemistry. A few facts about absorption by the above-mentioned compounds will be explained.

In spectrophotometry what is measured is the transmission of light of some definite wave-length through a dilute solution of the compound under investigation. It is usually more convenient actually to measure the logarithm of the reciprocal of the transmission. This quantity is know as the optical density where

$$D = \log\left(\frac{1}{T}\right)$$

In order to obtain a complete picture of the absorption throughout the range of wave-lengths, it is frequently necessary to use solutions of different concentrations and so it is the practice to express the optical density for some definite concentration and thickness of solution. The thickness of the transmitting solution is kept constant at one centimeter and the optical density is often expressed in terms of a one per cent solution. In such a case the optical density is referred to as the specific absorption. This is the quantity which has been plotted as ordinates in Figure 1. Actually, the logarithm has been plotted in order to reduce the vertical distance required for plotting.

We are chiefly interested in the amount of the absorption. For instance, when log E = 0, then E = 1. The optical density of a one per cent solution is also equal to 1. Since

$$D = \log\left(\frac{1}{T}\right) = 1$$

$$\text{and} \quad \frac{1}{T} = 10$$

$$\text{or} \quad T = 0.1 = 10\%$$

In other words, at the wave-length where the logarithm of the specific absorption is zero, 90% of that radiation is being absorbed. In fact, when log E = .3 then for all practical purposes the radiation is being completely absorbed, because the transmission is then only 1 per cent.

One per cent solutions in iso-octane of methyl methacrylate, benzoyl peroxide and benzoin show 90% absorption of radiations at 2750, 2950 and 3575 A.U. respectively. Pure methyl methacrylate should then absorb completely at 2750 A.U.

A qualitative experiment was made which gives some confirmation of these views. In four pyrex test tubes(pyrex does not pass wave-lengths below 3000 A.U.) were placed equal quantities of inhibitor-free methyl methacrylate. To one was added a small amount of benzoyl peroxide, to another a small amount of benzoin and to another benzoyl peroxide and benzoin. The tubes were then irradiated with light from the UA2 mercury vapor lamp for 80 minutes. At the end of this time, the uncatalyzed methyl methacrylate was not visibly changed. The contents of the tube with benzoyl peroxide were thickened to the consistency of warm honey, which indicates that benzoyl peroxide can act to some extent as a light-activated catalyst. The methacrylate with benzoin had set to a very stiff gel, which shows the effectiveness of the benzoin as a photo-catalyst. The contents of the fourth tube, with both catalysts, had become a soft gel. This suggests that the activity of the benzoin was adversely affected by the benzoyl peroxide.

We have not made an experiment where light of wavelength less than 3000 A.U. is used to irradiate methyl methacrylate. This would be interesting to carry out. In the penetration studies which we are making, it would now seem worth while to use benzoin alone rather than in conjunction with benzoyl peroxide.

Curing of Denture Base Material with Ultra-Violet

In the last report, some curves were shown for the Knoop hardness gradients in methyl methacrylate denture base material and inlay material cured by a combination of heat and ultra-violet light. We have continued this study with the new UA2 lamp although we have not had the lamp long enough to complete the study.

Figure 2 shows two curves representing Lucitone pink denture base material and Hue-lon inlay material (Shade 65) cured by a preliminary heat treatment at 135° F. for 2 hours in a plaster mold followed by 2 hours' irradiation with the unfiltered light from the UA2 lamp, the samples being 6 inches away from the source. Benzoin and benzoyl peroxide in concentrations of 0.1% were added to the monomer.

As in previous cases, the maximum hardness of about 16 is produced on the surface within this curing time and then falls off quite rapidly until a steady value of about 10.5 is obtained. Except for this lower value which has been increased from 10.0 the only notable difference in these results is that they have been produced in a much shorter time. In fact, the total time of 4 hours is now within the desired range for practical repair work on dentures.

Future Work

As was found with the work on low-temperature polymerization at 135° F. the Knoop hardness values do not indicate completely the suitability of a curing technique. It is, of course, desirable to produce the maximum hardness but, at the same time, the necessary strength should also be developed. We have already begun work to determine the transverse strength of some of the methyl methacrylate samples cured by heat and ultra-violet light. The data are not yet ready for inclusion in this report.

We are also continuing the study of the polymerization effects of ultra-violet light passed through filters. As indicated in the last report, this is a promising method of raising the overall degree of polymerization throughout the material. An investigation of the rate of cure as indicated by the Knoop hardness values would also appear to be a worthwhile undertaking. In this, hardness gradients would be determined for increasing exposure intervals to learn how the degree of polymerization actually develops.

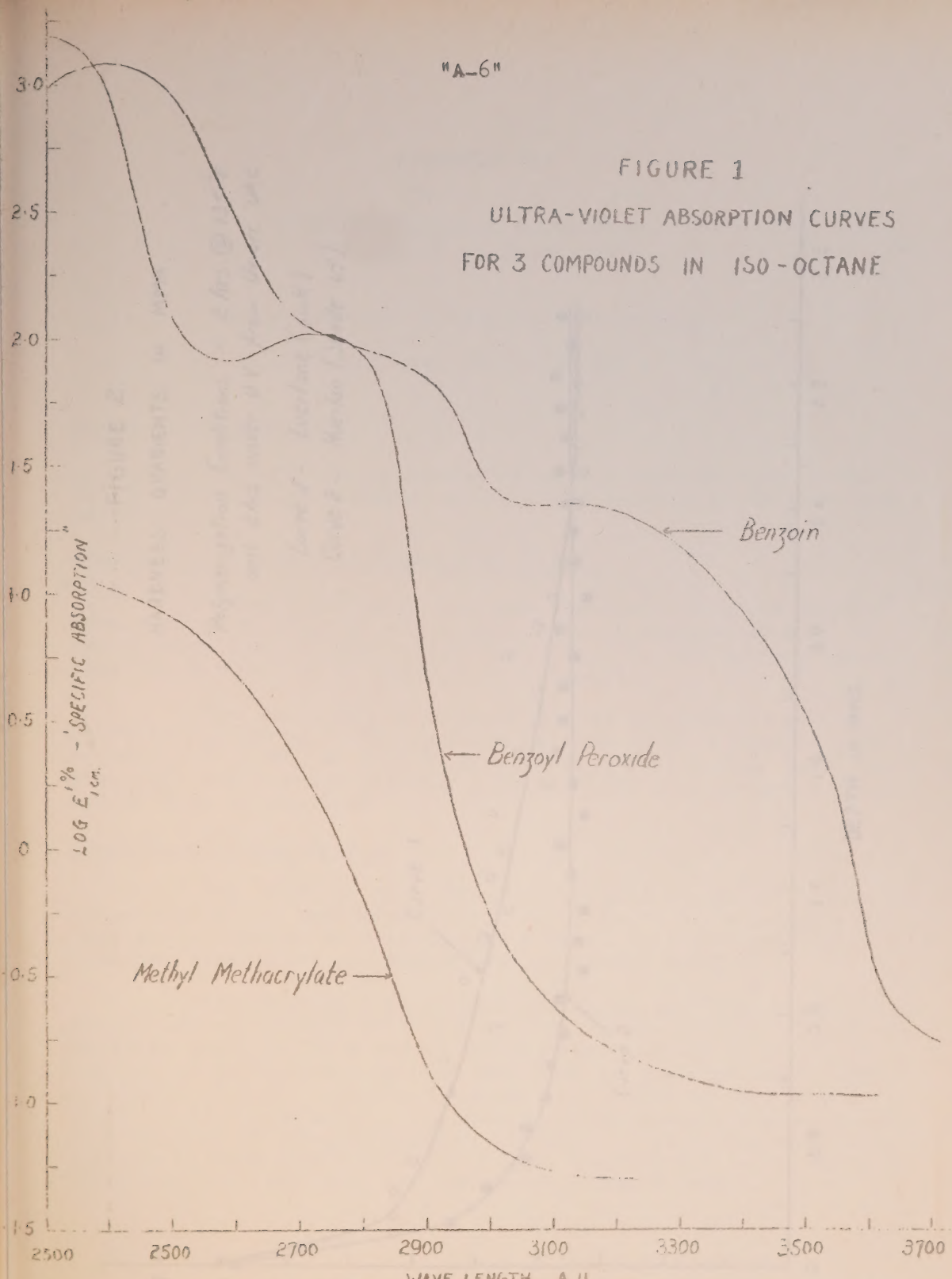
May 10, 1948

Douglas R. Christie
Research Fellow

FIGURE 1

ULTRA-VIOLET ABSORPTION CURVES

FOR 3 COMPOUNDS IN ISO-OCTANE



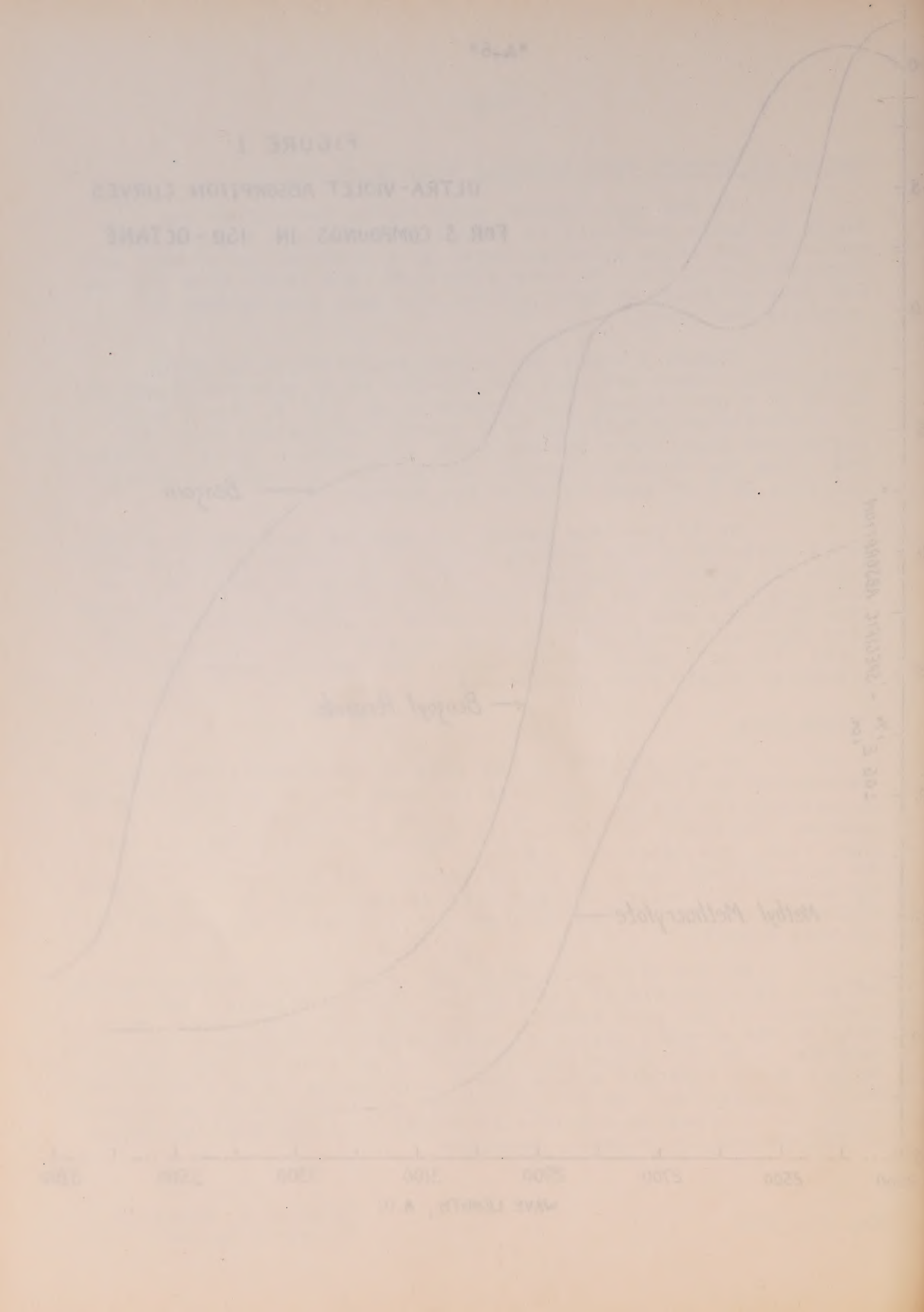


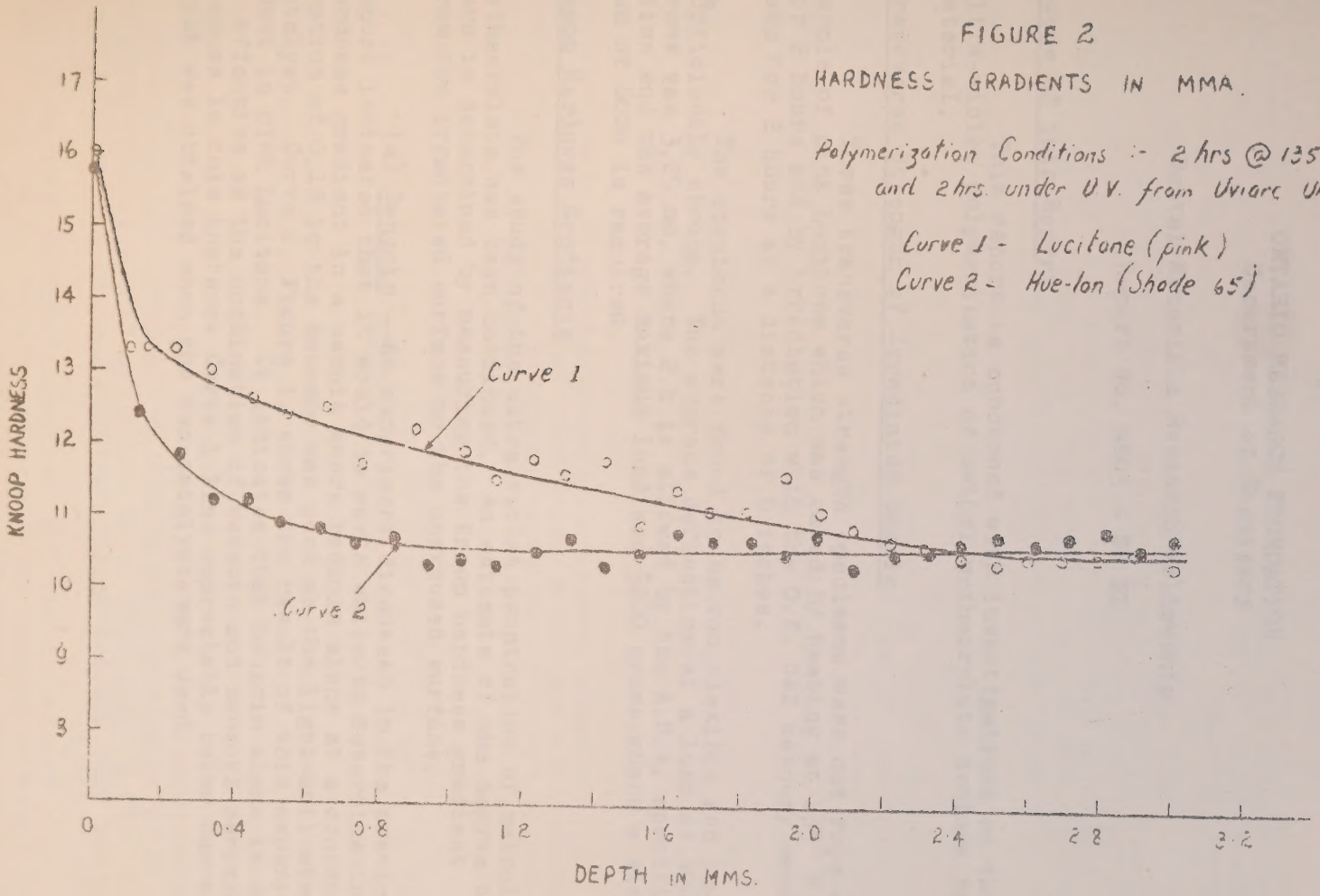
FIGURE 2

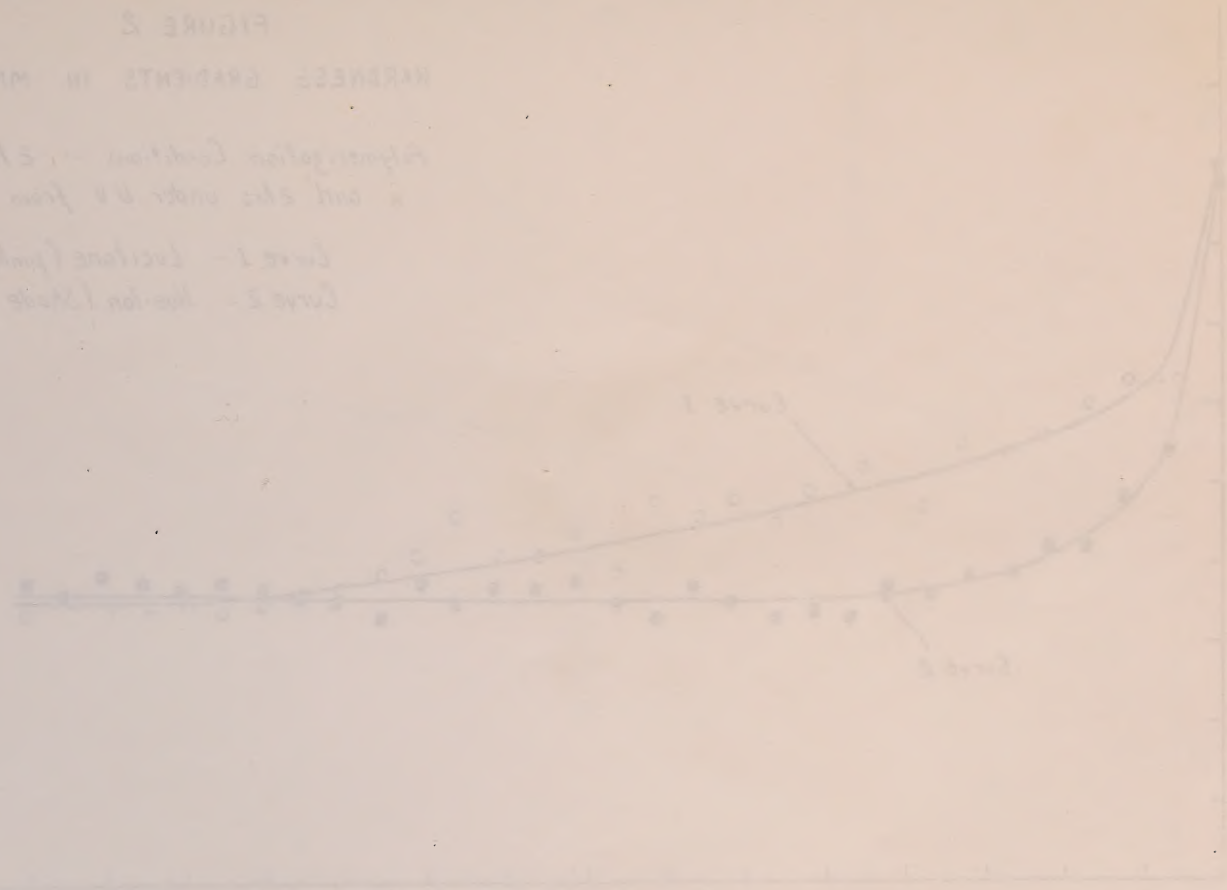
HARDNESS GRADIENTS IN MMA.

Polymerization Conditions :- 2 hrs @ 135°F. and 2 hrs. under U.V. from Uviarc UA2

Curve 1 - Lucitone (pink)

Curve 2 - Hue-Ion (Shade 65)





APPENDIX "A"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4805 - DR 21

Scope of this Report

This report is concerned with investigations on the ultra-violet polymerization of methyl methacrylate denture base material.

Transverse Strength of Irradiated Sample

Three transverse strength specimens were cut from a sample of pink Lucitone which was cured by heating at 135° F. for 2 hours and by irradiation with the G.E. UA2 mercury vapor lamp for 2 hours at a distance of 6 inches.

The specimens were found to be too flexible and insufficiently strong. The average deflection at a load of 4000 grams was 3.29 mm. where 2.6 is allowed by the A.D.A. specification and the average maximum load was 5200 grams where a minimum of 6000 is required.

Knoop Hardness Gradients

The study of the ultra-violet penetration of methyl methacrylate has been continued. An estimate of the degree of cure is determined by measuring the Knoop hardness gradient from the irradiated surface to the unexposed surface.

(a) Benzoin --An experiment discussed in the previous report indicated that it would be worth while to determine the hardness gradient in a sample where benzoin alone at a concentration of 0.1% in the monomer was used as the light-activated catalyst. Curve 1, Figure 1, shows the result of this experiment in pink Lucitone. It indicates that benzoin alone is not as effective as the combination of benzoin and benzoyl peroxide because in this instance Curve 1 lies appreciably below Curve 2 which was obtained when the two catalysts were used.

(b) Clear Methyl Methacrylate -- In order to study the effect of U.V. penetration on the polymerization of methyl methacrylate without the complications introduced by the presence of pigments, clear methyl methacrylate (Lucitone) denture base material was used.

All samples in these studies were given an initial heat treatment at 135°F. for 2 hours in a plaster mold in a dental flask and were then placed 6 inches from the UA2 mercury lamp and irradiated for 2 hours. The specimens were approximately of the dimensions 1/8" x 1"x3" and were heat-cured against glass microscope slides to produce smooth surfaces.

Curves 1 and 2 in Figure 2 show the hardness gradients obtained in 2 clear specimens. Once again the surface is quite hard and the hardness falls off rapidly with the thickness of the specimen. This effect has been obtained previously with pink Lucitone. It is, of course, our endeavor to avoid this rapid fall-off and to raise the over-all hardness of the specimen.

(c) Non-Reflecting Surfaces -- It was considered that the smooth exposed surfaces might be reflecting a large part of the incident U.V. light and that the efficiency of the radiation was low on this account. Accordingly, samples were heat-cured against glass plates which were ground as uniformly as possible with arbor bands. The surfaces produced against these ground glass surfaces were considerably less reflective than those produced against the smooth glass.

Hardness gradients in two clear specimens were determined when the exposed surfaces were made non-reflecting. Curves 3 and 4 in Figure 2 show these gradients. No appreciable difference is to be found between these and gradients in samples with smooth surfaces.

(d) Effect of Filters -- The hardness gradients produced in clear Lucitone when the U.V. radiations from the UA2 lamp were passed through various Corning glass color filters were also determined.

Three different filters were used. The code numbers of these filters were 9700, 9863 and 5970 and their spectral transmission characteristics are shown in Figure 3. It will be seen that No. 9700 transmits all wave lengths of light down to approximately 2600 Å ; No. 9863 passes still shorter wave-lengths down to about 2300 Å but cuts off all wave-lengths above 4200 Å and has a relatively flat peak with a maximum transmission at about 3200 Å ; No. 5970 is of a similar type with cut-offs at 3000 and 4200 Å and a maximum at 3650 Å.

Figure 4 shows the hardness gradients obtained with clear Lucitone samples which were irradiated for 2 hours after heat-curing for 2 hours at 135° F. There is little difference

Figure 4 shows the hardness gradients obtained with clear Lucitone samples which were irradiated for 2 hours after heat-curing for 2 hours at 135° F. There is little difference in the curves for filters 9700 and 9863 except for a slightly higher surface hardness for 9700. The curve for filter 5970 is of the same general shape but the hardness of the specimen is significantly lower throughout. This indicates that the wave lengths below 3000 Å are effective in promoting polymerization. It would appear, also, that wave lengths shorter than 2400 Å are responsible for the very high surface hardnesses which are found when unfiltered radiations are used. We propose to carry on this study with one more filter which will transmit still shorter wave lengths down to approximately 2100 Å.

It should also be mentioned here, that some discoloration of the resin is evident when no filters are employed. This discoloration is not regarded as serious and is not readily apparent in pink Lucitone. The use of filters eliminates or greatly reduces the discoloration, again indicating that very short wave lengths are responsible.

The fourth curve in Figure 4 -- 9863-B3 -- shows the gradient obtained when the benzoyl peroxide content in the monomer was increased to 0.3%. It was thought that the 0.1% concentration of peroxide might be entirely decomposed during the polymerization reaction with the result that the curing would be effectively terminated, so the peroxide concentration was increased. However this does not appear to be the case and it is obvious that 0.3% of benzoyl peroxide is too great a concentration. The low hardness values may possibly be caused by the benzoyl peroxide acting as a filter and not as an initiator. It was shown in the last report that benzoyl peroxide had two peaks in its U.V. absorption spectrum below 3000 Å and therefore it could act as a filter.

This point raises the question of what is the most effective concentration of a light-activated catalyst. Presumably the catalyst should be consumed in direct proportion to the extent of reaction so that an excess will not be present to absorb radiations which are necessary for the further polymerization of lower layers. Some data on this matter would no doubt assist materially to a clearer understanding of the entire subject. It would also be desirable to know more about the U.V. absorption spectrum of methyl methacrylate in several degrees of polymerization. In a recent paper[x] on an allied subject it

[x] Blout, E.R. et alia -- J. Polymer Sci. Vol. III, page 264, April, 1948.

is stated that lucite (probably completed cured methyl methacrylate) has a transmission of 50% at a wave length of 3100 Å. The thickness of the lucite was not specified. This means that the denture base material which we are polymerizing by U.V. radiations can in itself become a filter.

We have suggested this fact before in explaining the difference in the hardness gradients obtained with and without the use of filters. (Compare Figures 2 and 3). When no filter is used a high hardness value is found on the surface and the internal hardness drops off more quickly than when a filter is used and the surface is softer.

In the same paper mentioned above it was stated that the thermal polymerization of methyl methacrylate is essentially the same type as the U.V. induced polymerization and produces a similar polymer. This fact suggests that an attempt be made to carry out the U.V. polymerization at a higher temperature, for example 135° F.

The use of diacetyl as a light-activated catalyst has been frequently encountered in the literature. We have already suggested using this catalyst and plan to make experiments with it in the near future. Some investigations on the effect of the presence of pigments in the denture base material should be made and another variation of the present technique would be to decrease the distance between the U.V. lamp and the resin.

Future Work

The proposed future investigations can be summarized as follows:

1. Investigate the possibility of avoiding the production of a hard surface polymer by the application of a chemical anti-oxidant or by the exclusion of atmospheric oxygen by means of an inert gas or a layer of water.

2. Carry out irradiations at 135° F.

3. Investigate the use of diacetyl as a photo-initiator.

4. Determine the effect of the presence of pigments in the denture base material on the photo-polymerization.

5. Increase the effective intensity of the mercury vapor lamp by increasing the length of exposure and/or reducing the distance to the specimen.

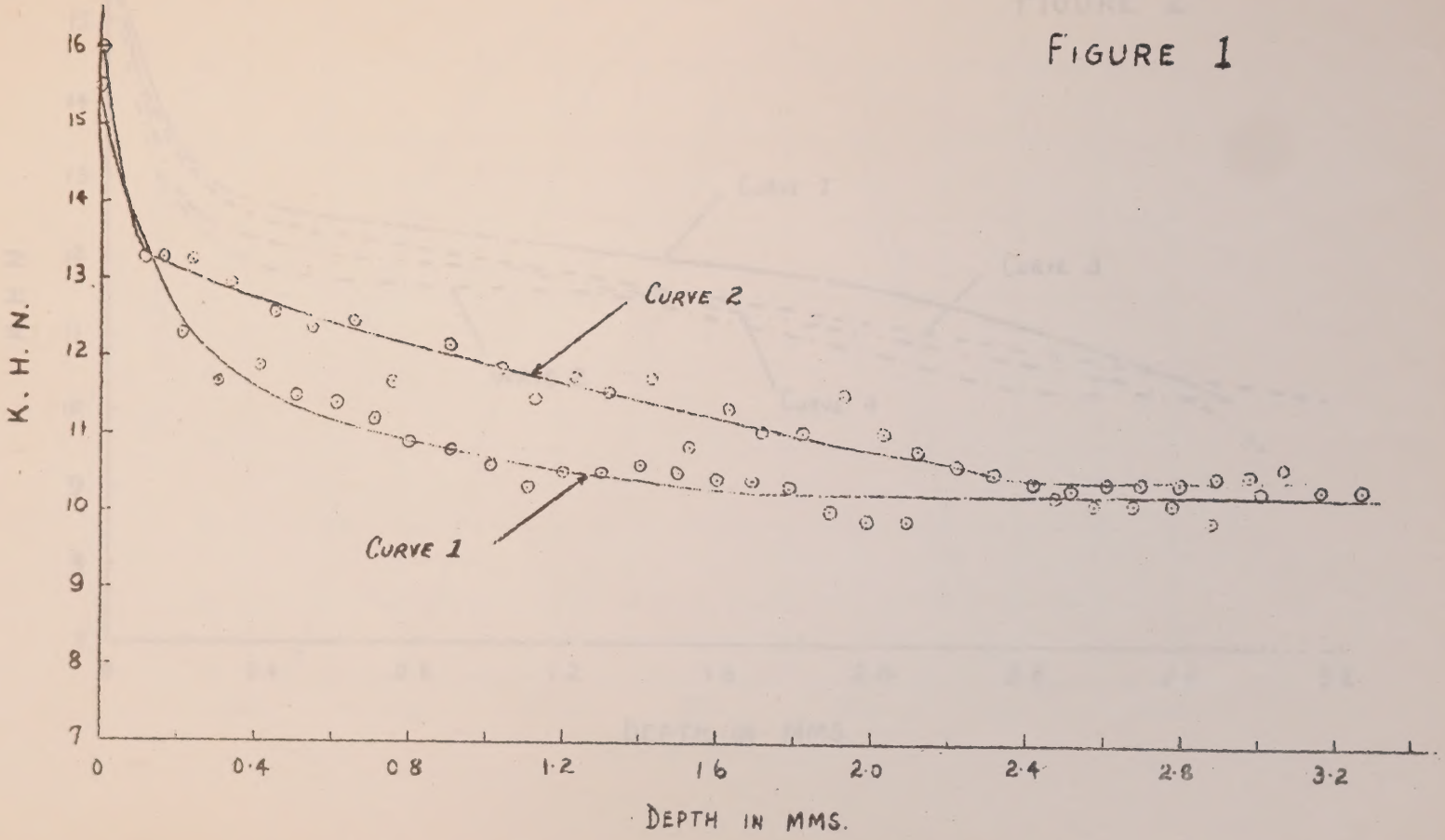
6. Determine the most effective concentrations of photo-catalysts.

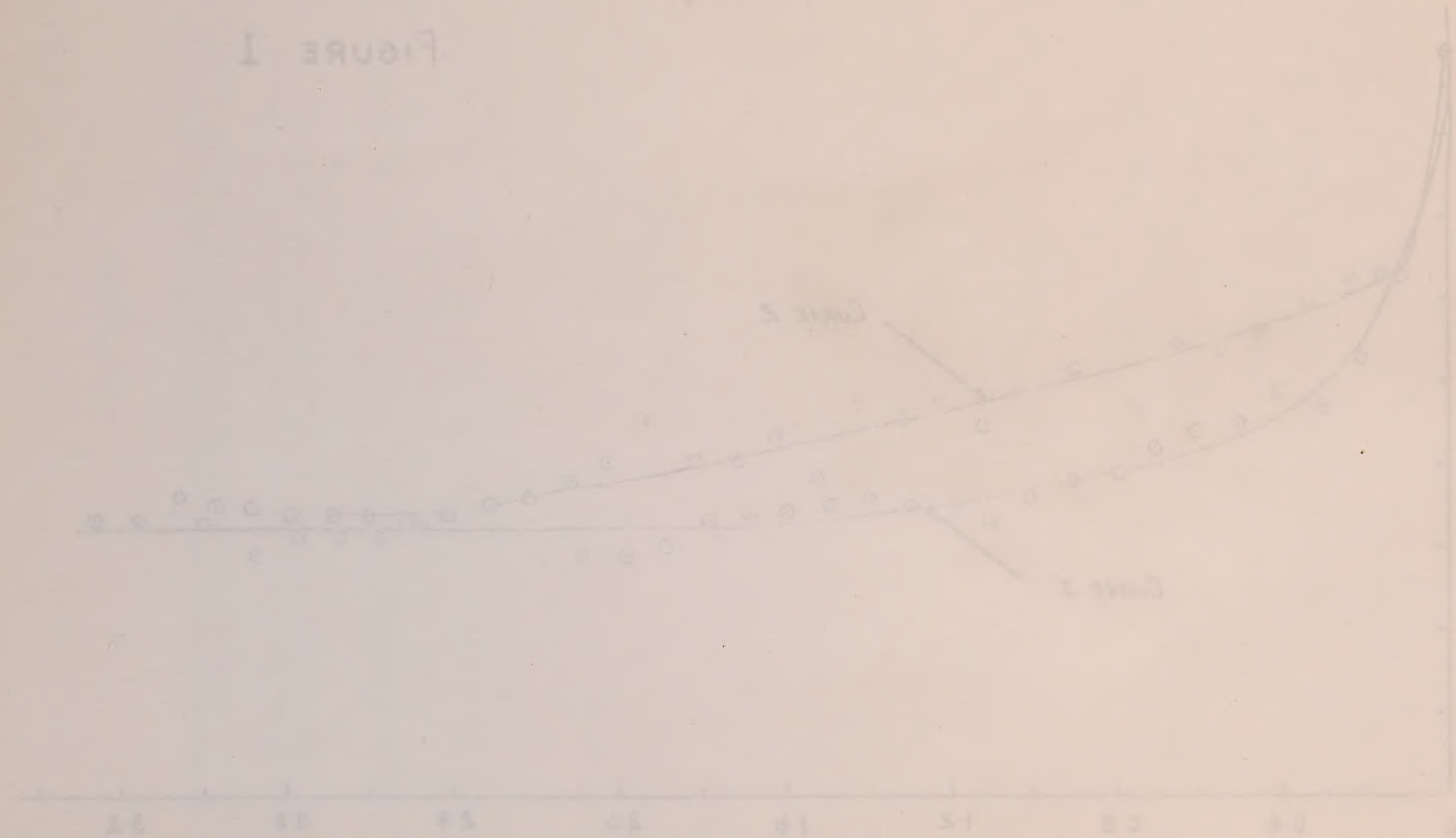
7. Obtain data on the U.V. absorption of methyl methacrylate polymer.

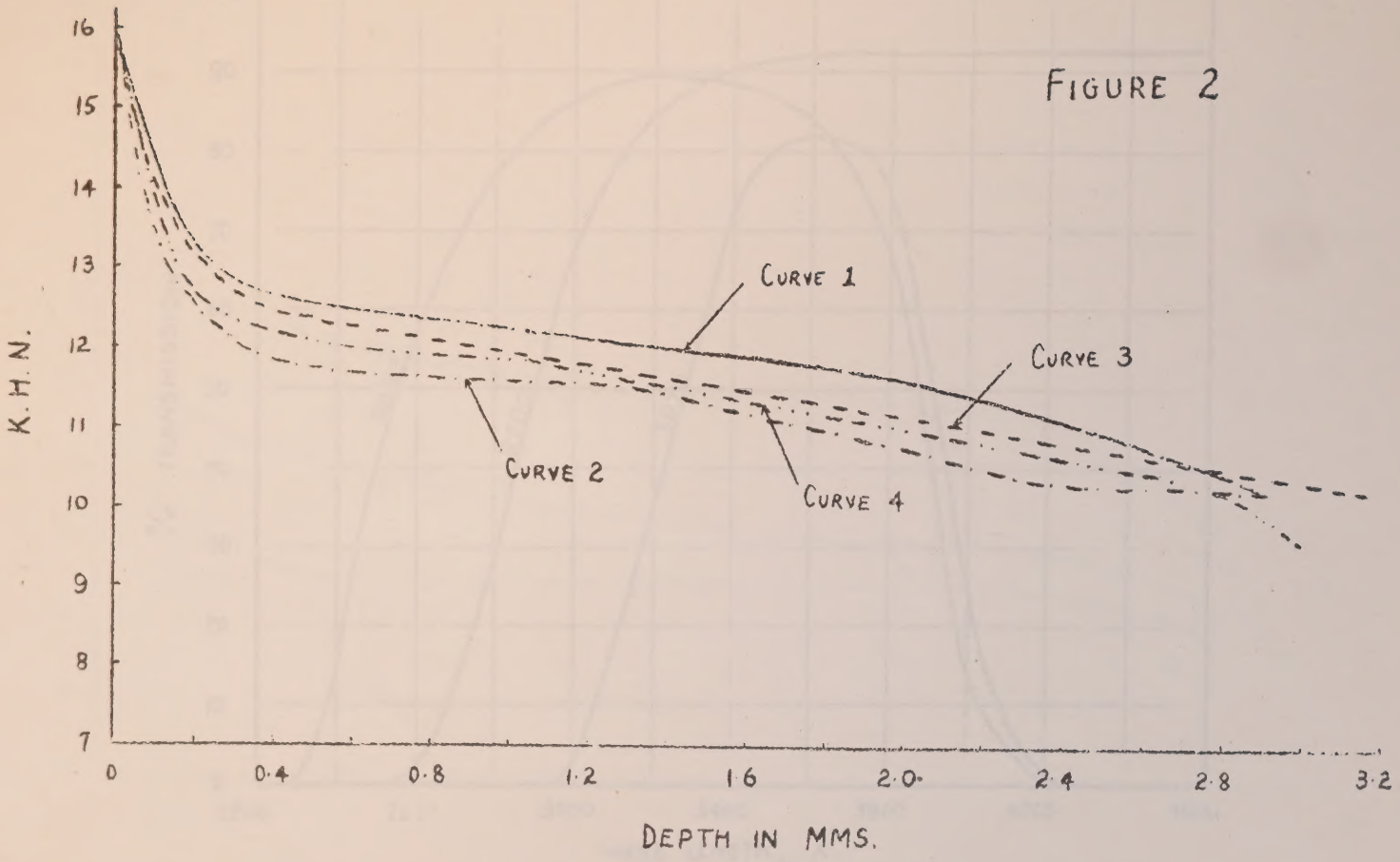
June 14, 1948.

Douglas R. Christie,
Research Fellow.

FIGURE 1


16
15
14
13
12
11
10
9
8
7
K. H. N.
0
0·4
0 8
1·2
1 6
2·0
2·4
2·8
3·2
DEPTH IN MMS.
CURVE 2
CURVE 1




16
15
14
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K.H.N.
0
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1·6
2·0
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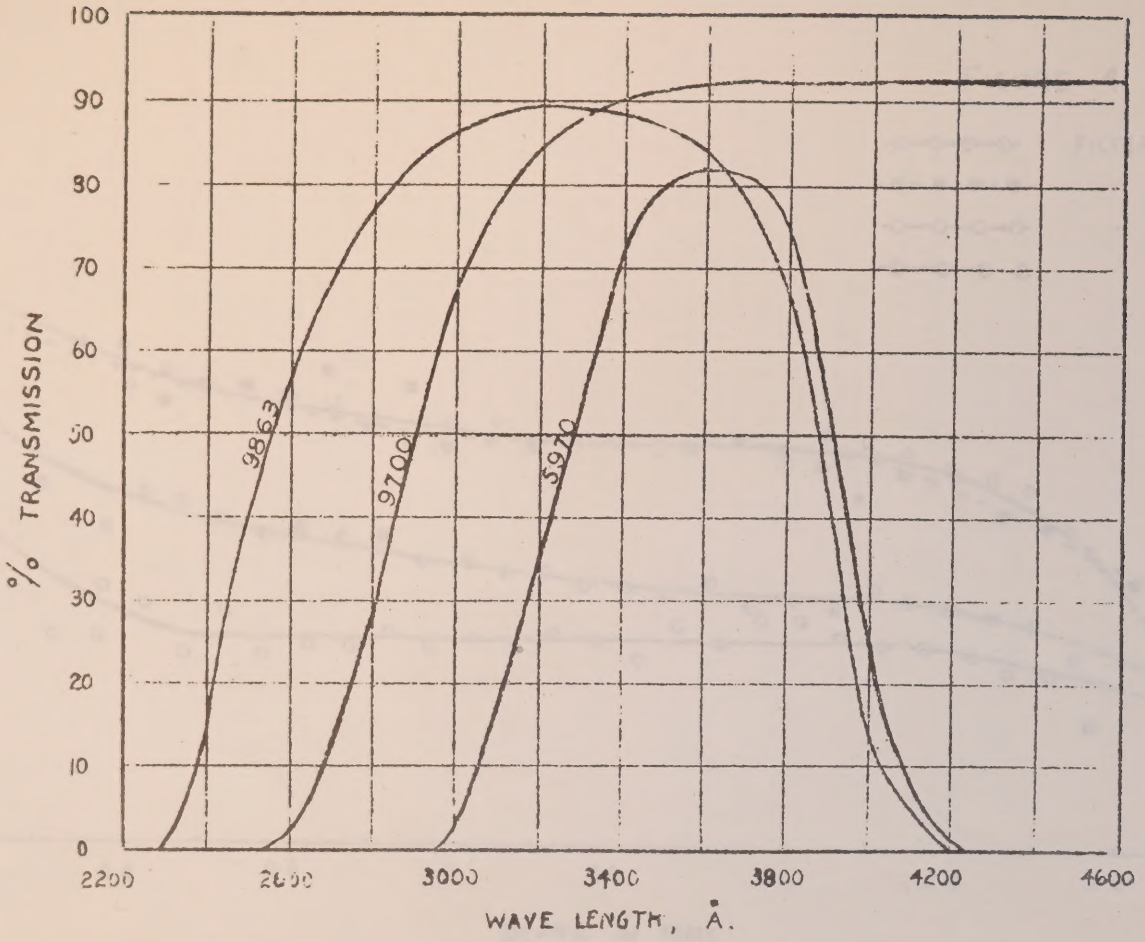
3·2
DEPTH IN MMS.
CURVE 1
CURVE 2
CURVE 3
CURVE 4

FIGURE 2

FIGURE 5

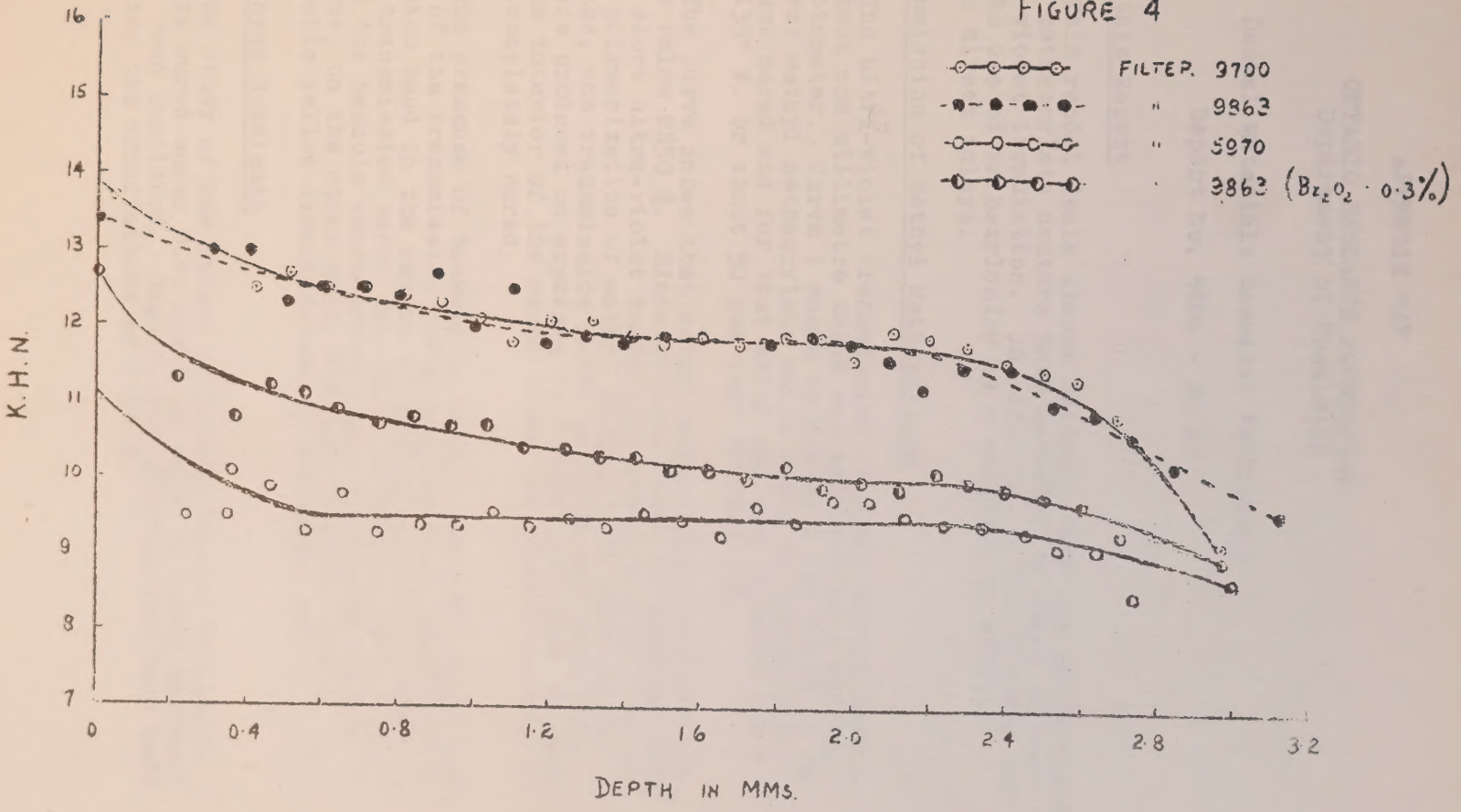
FIGURE 3.


100
90
80
70
60
50
40
30
20
10
0
% TRANSMISSION
9863
9700
5970
2200
2600
3000
3400
3800
4200
4600
WAVE LENGTH, Å.

0.06
0.04
0.02
0
WAVE LENGTH, λ
NOISE
NOISE
NOISE
% TRANSMISSION
0
20
40
60
80
100

FIGURE 3

FIGURE 4


FILTER 9700
" 9863
" 5970
" 3863 (Bz_2O_2 · 0·3%)
K.H.N.
16
15
14
13
12
11
10
9
8
7
0
0·4
0·8
1·2
1·6
2·0
2·4
2·8
3·2
DEPTH IN MMS.

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4806 - DR 21

Scope of this Report

This report deals almost entirely with the polymerization of methyl methacrylate denture base material by means of heat and ultra-violet irradiation. In addition, a few comments are made on the use of trihexylamine as a catalyst in acrylic resins for direct inlays.

U.V. Transmission of Methyl Methacrylate

The ultra-violet transmission of clear methyl methacrylate about one millimetre thick was measured on a Beckman spectrophotometer. Curve 1 shown in Figure 1 was found to be the same for methyl methacrylate which could be considered 100 per cent cured and for that which was heat treated for 2 hours at 135° F. or about 50 per cent polymerized.

The curve shows that methyl methacrylate absorbs all radiations below 2850 Å. Since we have shown in previous work that very short ultra-violet radiations are more effective in promoting polymerization of methyl methacrylate than longer wave-lengths, the transmission curve explains why very hard surfaces are produced on exposure to direct U.V. from the lamp and why the interior of the resin below the exposed surface is much less completely cured.

The presence of benzoin in methyl methacrylate alters the shape of the transmission curve because this compound has an absorption band in the region of 3200 Å. Curve 2, Figure 1, shows the transmission curve when 0.1% of benzoin is present. Increasing the benzoin concentration will intensify the absorption but, on the other hand, too much benzoin causes an undesirable yellow discoloration in the cured resin.

Knoop Hardness Gradients

The study of the extent of polymerization of methyl methacrylate cured under U.V. light as shown by Knoop hardness values has been continued. Significant progress has been made by conducting the irradiations at 135° F.

(a) Diacetyl. This compound was substituted in whole and in part for benzoin and irradiation was carried out as previously at or near room temperature. No outstanding advantage in the use of diacetyl was found. In view of the yellow colour which it imparts to the resin in concentrations of 0.1% or greater, its use did not seem to be justified.

(b) Irradiation at 135° under Water. Inasmuch as the polymers produced by heat and by U.V. light are stated to be identical, it seemed desirable to carry out the irradiations at an elevated temperature where polymerization would be expected to proceed more rapidly and to a greater extent.

The first experiment in this series was to polymerize clear methyl methacrylate containing 0.1% of benzoin and 0.1% benzoyl peroxide in the monomer at 135°F. under a thin layer of water about 1 to 3 mm. thick. As before, the resin was given an initial heat treatment in a plaster mold in a dental flask for 2 hours at 135°F. At the end of this time, the flask was opened and the half containing the resin was suspended in a water bath at 135°F. so that the exposed surface was covered with a thin layer of the bath water. Irradiation was carried out for 2 hours with the unfiltered rays from a G.E. 250 watt UA 2 mercury vapour lamp placed six inches from the resin.

The hardness gradient produced in the resin is shown by Curve 1, Figure 2. In this case, we find a linear, nearly horizontal curve. The unexposed surface hardness has been raised to about 14, a considerable increase over previously obtained values. The hardness of the exposed surface is less than that obtained on direct exposure at room temperature. Evidently the water layer has prevented the formation of a very hard polymer.

A transverse strength test was carried out on one sample cut from a piece of methyl methacrylate cured in this manner. The strength of the material was found to be satisfactory.

It was hoped that the layer of water would prevent the development on the exposed surface of the usual tackiness and haziness. It did to some extent but not completely. However, these surface effects are not serious and can easily be removed by buffing.

(c) Irradiation at 135° under CO_2. The same procedure as outlined above was carried out here with the exception that carbon dioxide was passed over the surface of the resin replacing the layer of water. Carbon dioxide was used in an effort to avoid the surface effects of tackiness and haze.

Although the carbon dioxide was unsuccessful for this purpose, the resin was cured to an even greater extent than when it was covered by water. The hardness gradient obtained in this case is shown by Curve 2, Figure 2.

For comparison of the gradients, a similar experiment was made, differing only in that the irradiation was carried out at approximately room temperature or about 85°F. Curve 3, Figure 2, shows the results which were obtained. The unexposed surface is considerably softer than when the irradiation is done at 135° F.

(d) Irradiation at 135°F. under direct U.V. The hardest resin was produced when neither water nor CO_2 was used but when the specimen was exposed to the direct rays from the mercury vapor lamp. As before, 0.1% of both benzoin and benzoyl peroxide were added to the monomer and polymerization conditions were 2 hours at 135°F. in a dental flask and 2 hours under the lamp at a distance of 6 inches and at 135°F.

In this case, the entire mass of the resin is very hard, the exposed surface being above 17 and the unexposed surface between 15 and 16. The hardness gradient is shown as Curve 4, Figure 2.

Discoloration

It was observed in most instances that a yellow discoloration of the clear resin occurred. Although this effect is intensified by the presence of relatively large concentrations, say about 1 per cent, of photo-catalysts such as benzoin and diacetyl, it is still evident to a lesser extent when small concentrations are used.

Re-crystallization of the benzoin from ethyl alcohol to remove impurities failed to eliminate the discoloration. The use of a glass colour filter, Corning No. 9863, was also ineffective. In addition, the filter reduces the intensity of the U.V. lamp and thereby produces a softer polymer. An interesting fact which was observed in many cases is that the discoloration fades with time. Indeed, one piece of clear methyl methacrylate which was obviously discolored, could not be distinguished from other good specimens after a period of three weeks.

The writer believes that the discoloration problem is not serious. When pink denture base material is used, the difference in colour between a specimen cured by heat alone and one cured by heat and ultra-violet light is almost indiscernible.

Surface Hardness - Time Study

The rate of development of hardness of the plastic test specimens was studied to determine the optimum exposure to U.V. radiations to obtain a satisfactory polymer.

In this study, both clear and pink methyl methacrylate denture base materials were investigated. The specimens were first given a 2-hour heat treatment at 135°F. in a plaster mold in a dental flask. The sides of the mold were lined with glass microscope slides which imparted smooth, glossy surfaces to the resin which were ideal for making Knoop hardness determinations. The specimens measured approximately 3 x 25 x 75 mm.

After the preliminary heat treatment, which hardened the plastic to the extent that the mold could be opened without danger of distortion, the specimens were irradiated with the G.E. 250-watt UA2 mercury vapor lamp, placed 6 inches away. Knoop hardness measurements were then made on exposed and unexposed surfaces at the end of definite time intervals, usually 20 or 30 minute periods. Experiments were carried out at 135°F. by placing the mold in a thermostatically controlled water-bath and approximately at room temperature or probably near 85°F.

Figure 3 shows the relationship between the Knoop hardness number and the time of exposure to U.V. radiations for clear methyl methacrylate. It should be noted that the initial hardness, 9.1, at zero time is the Knoop hardness number at the end of the 2-hour heat treatment at 135°F. At 135°F. the exposed surface becomes hard quite rapidly and reaches a maximum of about 17 in one hour. The unexposed surface requires 2 hours to reach a hardness of slightly over 15. If 14 is arbitrarily set as the minimum hardness desirable in the sample, then an exposure of 55 minutes would be required. At room temperature the exposed surface reaches a maximum hardness of 16 in an hour but the unexposed surface is only 11.5 after 2 hours exposure. Obviously it would be impossible in this length of time for the sample to reach a minimum hardness of 14. The fifth line shows that the hardness of the entire sample increases very slowly with heat alone at 135°F.

Figure 4 shows a similar set of data for pink denture base material. The time - K.H.N. curve for the exposed surface at room temperature has been assumed to be the same as for clear methyl methacrylate because experience has shown that the maximum hardness for pink is also about 16. Previous results have indicated that the unexposed surface of a pink specimen about 3 mm. thick attains a hardness of approximately 10.8, so the curve for the unexposed surface has been postulated.

Under U.V. radiations at 135°F., the exposed surface again hardens rapidly, reaching 17 in about an hour but increasing to a higher maximum of 18. The unexposed surface, however, reaches a maximum of only 12.6 after 2 hours' irradiation. This result is no doubt due to the presence of pigment which prevents the polymerizing radiations from penetrating through the sample. With pink denture base material, the arbitrary minimum hardness of 14 can never be attained throughout the sample in the 2-hour curing period. In this instance, then, the criterion of the suitability of the plastic for dentures should not be hardness but transverse strength.

Transverse Strength

It could be seen from Figure 4 that at the end of one hour and a half the hardness of the sample was not changing with continued irradiation. Presumably, the transverse strength was also remaining relatively constant. At the end of an hour the hardness was still changing but had nearly reached its maximum. It was thought possible that the resin had become strong enough at the end of this period.

Accordingly, samples of pink methyl methacrylate were prepared for transverse strength tests. One group was cured by irradiation for 1 1/2 hours and another by irradiation for 1 hour. The results are listed in the following table.

Transverse Strengths of U.V.-Cured Resins

	Deflection in mms.		
Load in Grams	1 Hour	1 1/2 Hours	A.D.A.Specifications
4000	3.12	2.59	2.6
6000	--	6.2	3 to 8
Av. Maximum Load	5900	7000	must be 6000

The methyl methacrylate cured for 1 hour under U.V. is too weak and too flexible, while that cured for 1 1/2 hours meets the specifications of the test.

Hardness Gradient in Pink Methyl Methacrylate

Following the successful method of curing pink denture base material by heat and U.V. irradiation at 135°F., the hardness gradient in a sample of this material about 3 mm. thick was determined.

This gradient is shown in Figure 5. It is almost linear extending from about 18 on the exposed surface to 12.5 on the unexposed surface. In fact at a depth of 2.5 mm., which is probably as thick or thicker than any new material added in a repair is likely to be, the hardness is 13.5.

Repairing Dentures

At this writing several dentures have been repaired using the method of heat and irradiation. No evidence of distorition of the dentures has been observed and the colour of the repairs appears to match that of the original denture base material very well.

The method requires a suitable thermostatically controlled water bath and a mercury vapor lamp. The cost of this apparatus is moderate and the operating expense is low. A repair is prepared and started in the usual manner. After 2 hours' heating at 135°F., the flask is opened and the new material irradiated for 1 1/2 hours with the flask immersed to its rim in the bath at 135°F. The total time involved is 3 1/2 hours in addition to the time required for preparation and polishing.

Trihexylamine

A sample of trihexylamine has been obtained. This is the material which is claimed to have been used successfully in Germany as a catalyst for the rapid polymerization of methyl methacrylate used for direct inlays.

A few qualitative tests have been made to date. The presence of trihexylamine in a monomer-polymer mixture causes the "kick-over" reaction to begin sooner and at a temperature 15 to 20° lower than when it is absent.

After 2 hours at 135°F., a sample of methyl methacrylate denture base material containing 1.0% trihexylamine and 0.1% benzoyl peroxide had a Knoop hardness number of 10.8, as compared with 9.1 when no trihexylamine was used.

Attempts have been made to make direct acrylic inlays in extracted teeth using 3.0% trihexylamine in the monomer and 0.5% benzoyl peroxide in the polymer powder. The source of heat for these experiments was a 250-watt infra red lamp. Although the heat obtainable from this lamp cannot be easily directed on the inlay alone and is far in excess of a safe maximum for dental applications, inlays could be polymerized in from five to ten minutes.

There are strong indications, therefore, that the use of trihexylamine together with a small infra-red source fitted with a lens system for focusing the heat could be successful in making direct inlays. A considerable amount of experimental work will be necessary before a satisfactory technique is devised. It should be possible, also, to make repairs on dentures by this method, using the larger infra-red lamp, in less than the 3 1/2 hours required by the ultra-violet irradiation method.

September 2, 1948.

Douglas R. Christie,
Research Fellow.

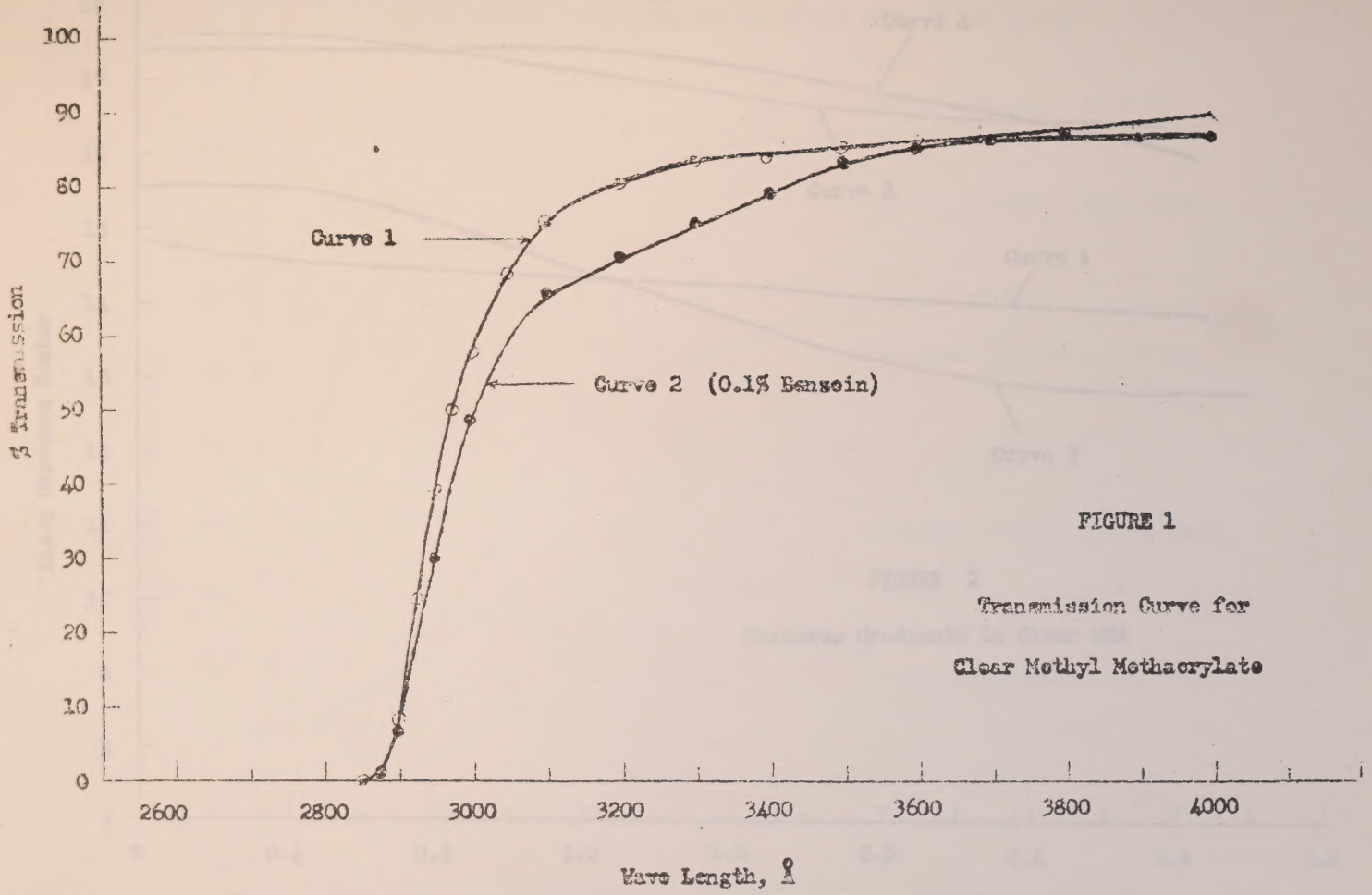
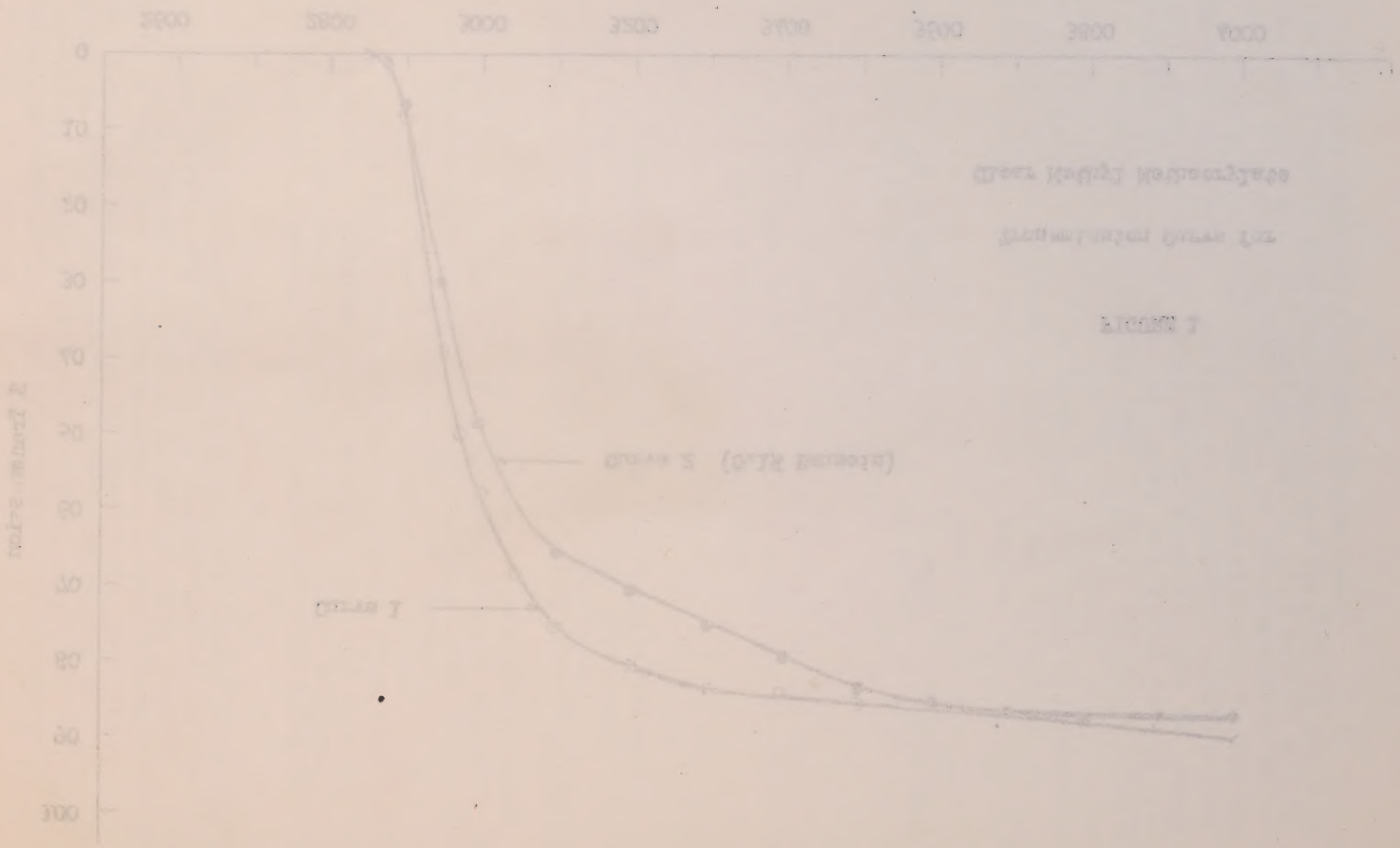


FIGURE 1

Transmission Curve for

Clear Methyl Methacrylate



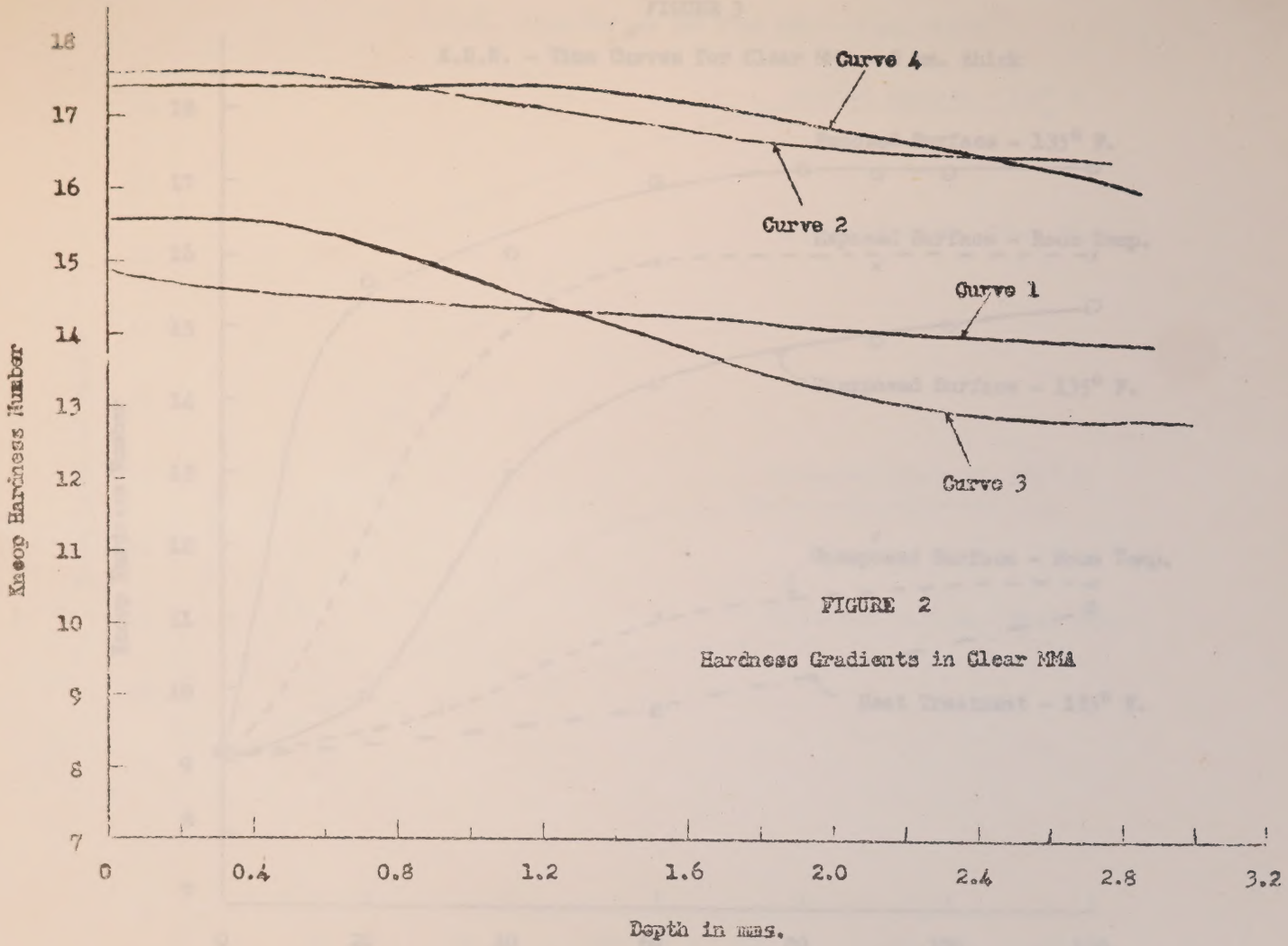


FIGURE 2

Hardness Gradients in Clear MMA

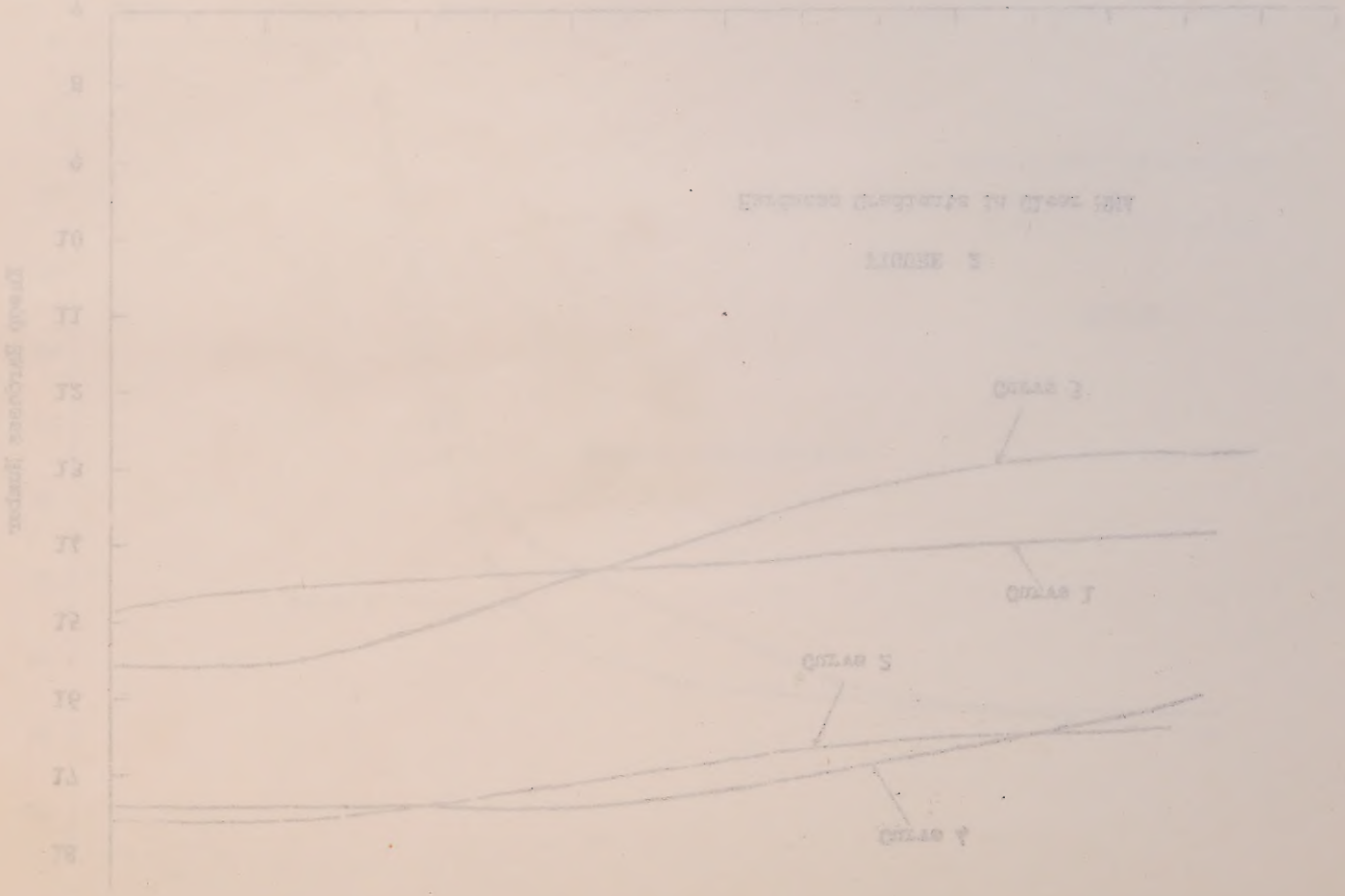
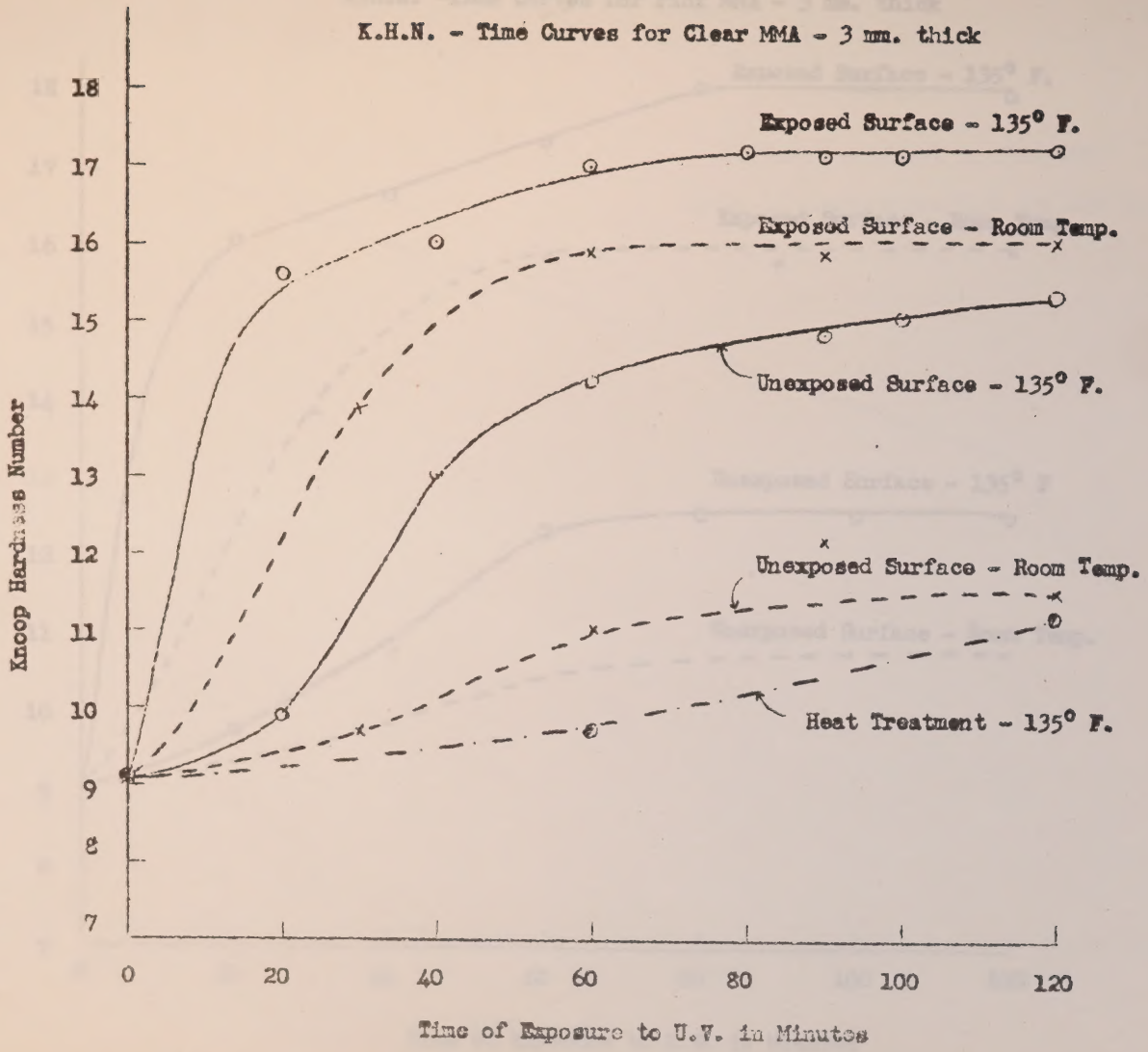

Gauge 3
Gauge 1
Gauge 2
Gauge 4

FIGURE 3


K.H.N. - Time Curves for Clear MMA - 3 mm. thick
Exposed Surface - 135° F.
Exposed Surface - Room Temp.
Unexposed Surface - 135° F.
Unexposed Surface - Room Temp.
Heat Treatment - 135° F.
Knoop Hardness Number
18
17
16
15
14
13
12
11
10
9
8
7
0
20
40
60
80
100
120
Time of Exposure to U.V. in Minutes

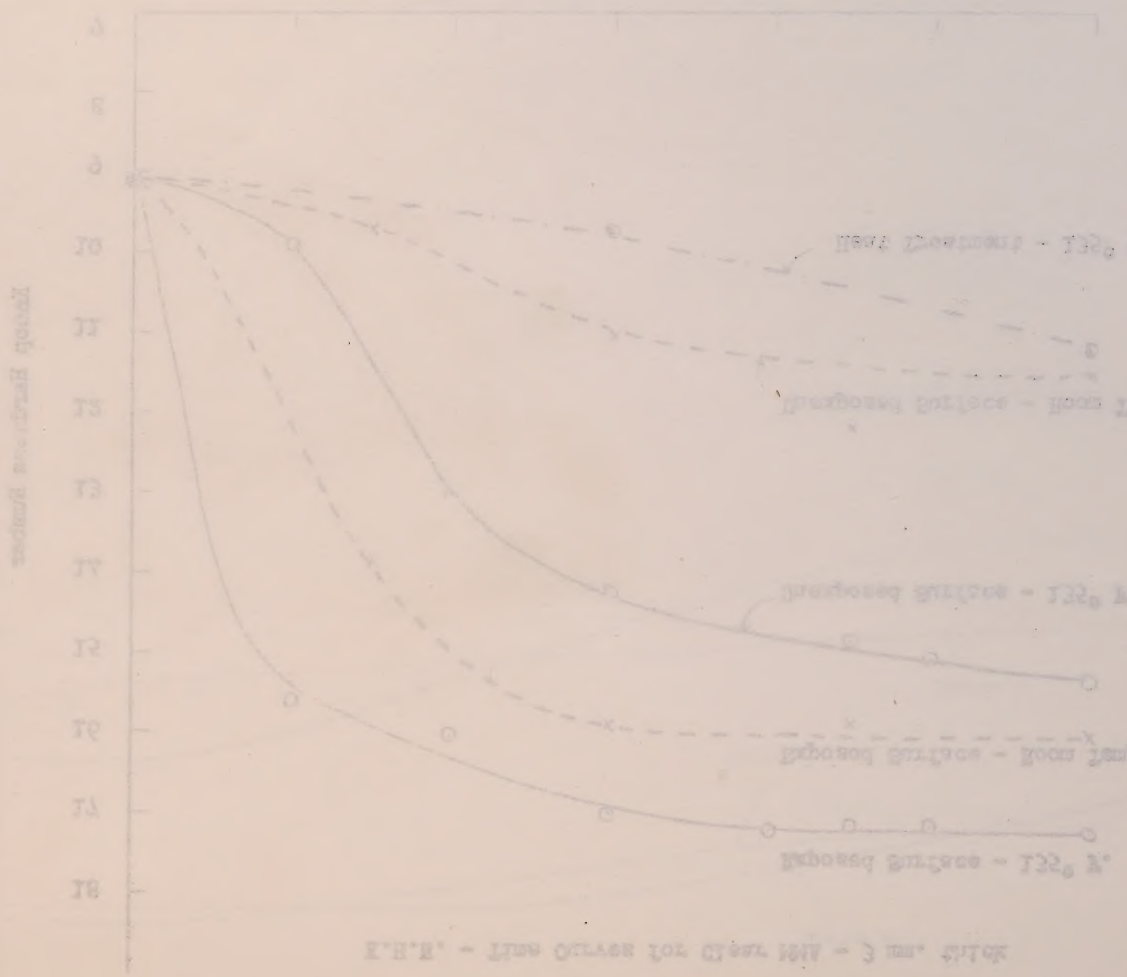
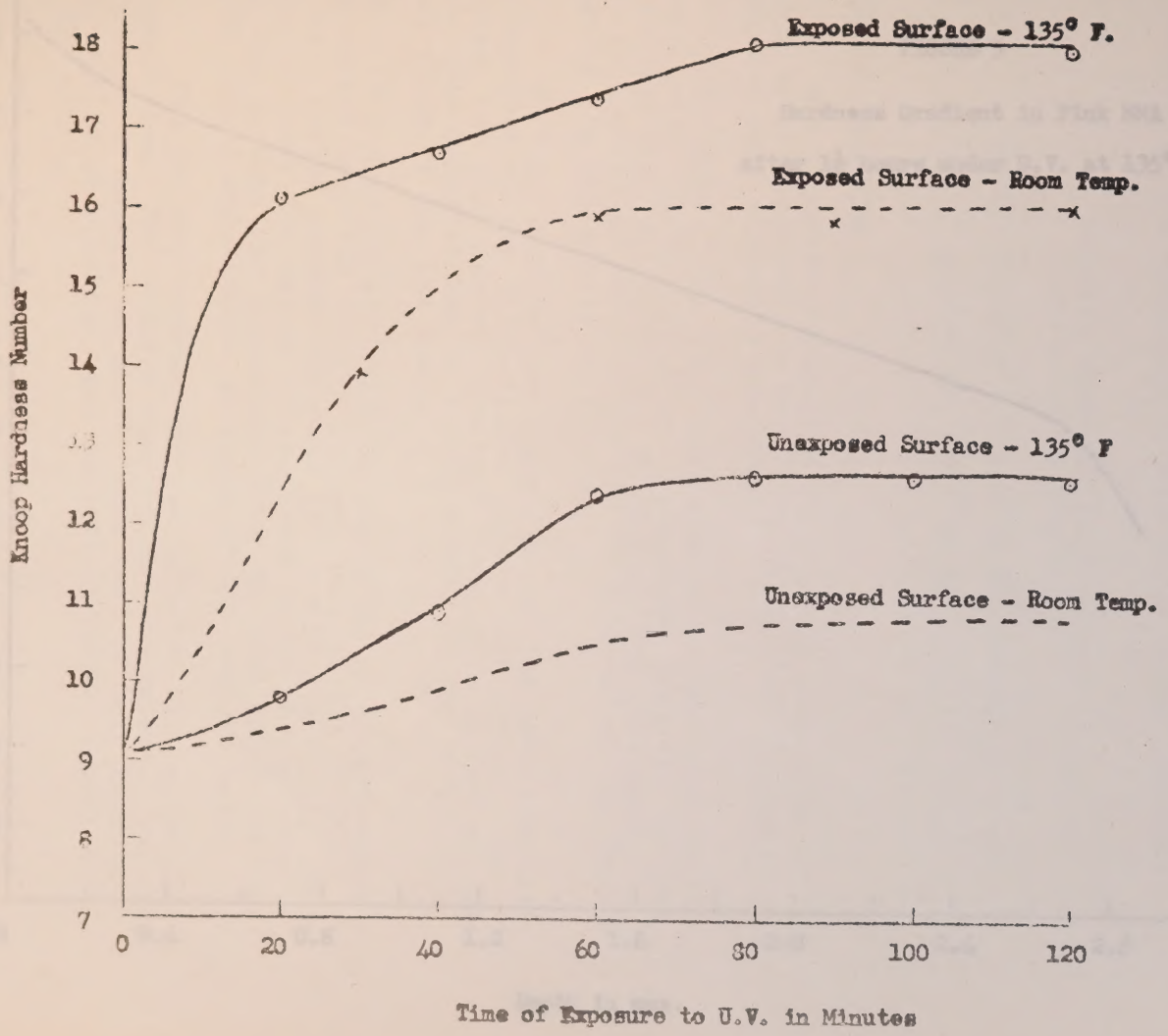


FIGURE 4

K.H.N. -Time Curves for Pink MMA - 3 mm. thick



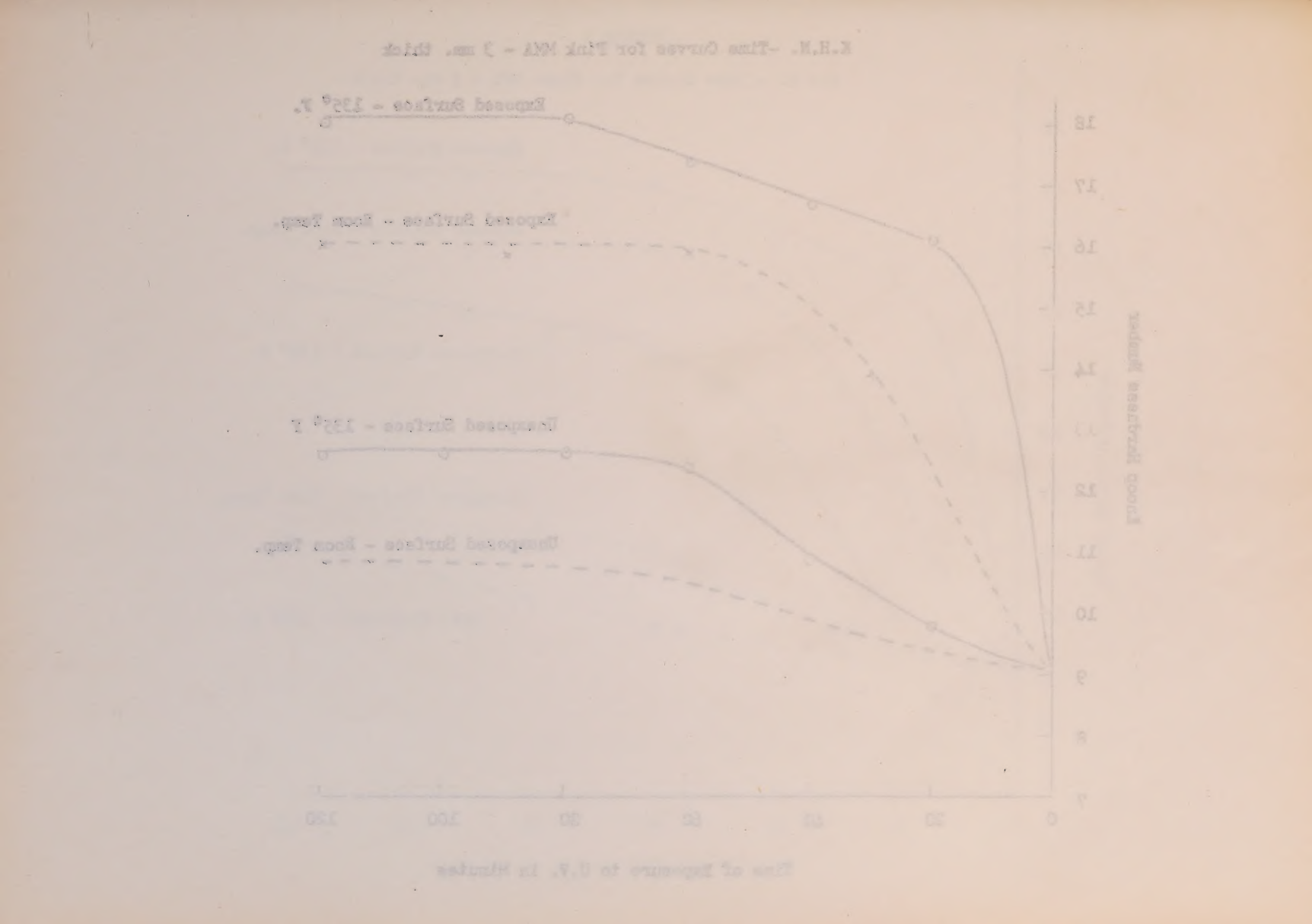
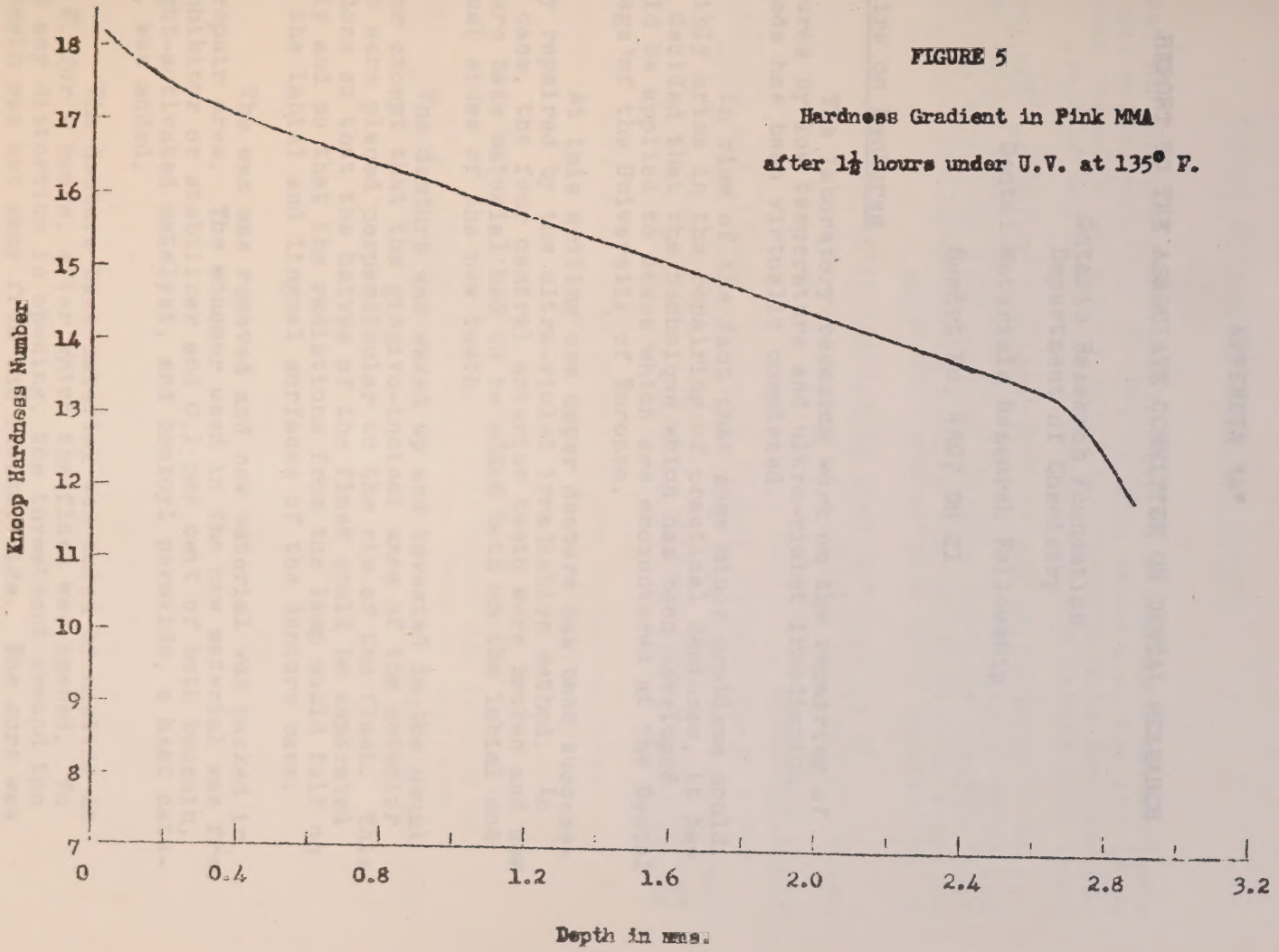


FIGURE 5

Hardness Gradient in Pink MMA

after 1½ hours under U.V. at 135° F.



Number of good increases
0
2
4
6
8
10
11
12
13
14
15
16
17
18
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2

APPENDIX "A"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Ontario Research Foundation
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4807 DR 21

Repairs on Dentures

The laboratory research work on the repairing of dentures by low temperature and ultra-violet irradiation methods has been virtually completed.

In view of the fact that some minor problems could possibly arise in the repairing of practical dentures, it has been decided that the technique which has been developed should be applied to cases which are encountered at the Dental College of the University of Toronto.

At this writing one upper denture has been successfully repaired by the ultra-violet irradiation method. In this case, the four central anterior teeth were broken and new denture base material had to be added both on the labial and lingual sides of the new teeth.

The denture was waxed up and invested in the usual manner except that the gingivo-incisal axes of the anterior teeth were placed perpendicular to the rim of the flask. This was done so that the halves of the flask could be separated easily and so that the radiations from the lamp would fall on both the labial and lingual surfaces of the denture base.

The wax was removed and new material was packed in the repair area. The monomer used in the new material was free of inhibitor or stabilizer and 0.1 per cent of both benzoin, a light-activated catalyst, and benzoyl peroxide, a heat catalyst, was added.

The denture base material was cured by heating at 135° F. for 2 hours, after which the flask was opened. To avoid any distortion in opening, the investment around the new teeth was cut away from the incisal side. The cure was

completed by immersing that half of the flask holding the denture up to the rim in a water bath at 135° F. and irradiating the new material with ultra-violet light from a UA2 250-watt mercury vapor lamp placed approximately 6 inches from the denture.

The denture was then trimmed and polished. The repair was quite successful in that the new material could hardly be distinguished from the original denture base and there was no evidence of distortion; the denture showed excellent adaptation to an occlusal index made before investing.

It is expected that additional dentures will be repaired in the near future.

Other Materials

A new denture repair material, Nuweld, has recently been presented which will cure, it is claimed, without the application of heat in about 15 minutes. If true, it would appear to be a most convenient means of making repairs.

October 18, 1948

Douglas R. Christie
Research Fellow.

APPENDIX "B"

FACIAL PROSTHESES OF VINYL RESINS

by

Dr. G.M. MacDonald

This report covers our work with this material to date. On account of the great amount of experimentation and research being continuously applied to these materials, in their professional and commercial applications, the status of Vinyl Resins is in constant flux. Therefore, our conclusions to date cannot be considered final.

Vinyl Resins are receiving considerable attention in their application to the production of cosmetic facial and hand prostheses which are considered an adjunct to other medical treatment. A good deal of work on Vinyl Resins is being carried out at several American Veteran and Service Centers which I had the privilege of visiting in February 1948.

A number of individuals are also producing this type of restoration for private patients, with varying degrees of success.

Several commercial companies are marketing Vinyl Resin compounds, in a prepared form, for use in prosthetic construction.

The work at Queen Mary Veterans' Hospital was stimulated by the need to supply facial prostheses for defects resulting from battle casualties and burns. Much of this work is a continuation of similar work which was begun Overseas during the late war.

31 May, 1948.

REPORT ON D.R. No. 10

by

Dr. G.M. MacDonald

FACIAL PROSTHESES OF VINYL RESINS

Reasons for Research

The object of this project was to record the results of our work and experiments with Vinyl Resins and to estimate their value for use in Facial Prostheses.

Vinyl Resins

Vinyl Resins are produced from cellulose which is derived from either wood pulp or cotton linters. The Vinyl radical is one of the Cellulose esters resulting from the acidification of the cellulose.

VINYL is the ethylene part of a molecular chain having the general formula $X.CH:CH_2$ where X is another radical having the same valence as H.

Vinyl Chloride, is produced by the action of chlorides on the Vinyl radical and combines with itself to form Poly-vinyl Chloride.

Poly-Vinyl Acetate, is similarly produced by the action of Acetates on the Vinyl radical.

These two products Polyvinyl Chloride and Poly-Vinyl acetate are usually combined in a ratio of 86-95% P.V.C. to 14-5% P.V.A. to produce a fine white powder which is known as a co-Polymer.

Products of this general type, but of unknown formulae, are supplied by Canadian Resins and Chemicals Limited and also by American Chemical companies, under trade names such as:

a) "Vycanac", with code, V.Y.N.V. No. 1

b) "Vinylite", with code, V.Y.N.V. No. 2

The powdered co-polymer, or poly-vinyl-chloride-acetate compound, is plasticized by mixing thoroughly with a plasticizer.

Plasticizers

The plasticizers for this use are alkyl pthalates which are esters or ethers of low volatility. The most common in use are Di-butyl pthalate and di-octyl pthalate.

These plasticizers are marketed, either pure or modified, under trade names. We are now using a Di-octyl pthalate plasticizer known as "Flexol" - D.O.P. Plasticizer, and is supplied by Carbide and Carbon Chemicals Corporation.

The mixing, or plasticizing, of the co-polymer with Di-octyl or Di-butyl pthalate results in a smooth mixture of thick syrupy consistency which when processed by heat curing is of a rubber like texture, almost transparent and colorless.

In order to produce a material with a desirable appearance and acceptable stability, various coloring agents and other ingredients are added to the mixture.

Following is a formula which we have found fairly satisfactory.

Formula Basic

Powder:

Poly-vinyl-chloride acetate (co-polymer)	4 ounces.
a) Titanium dioxide	3-4 grains.
b) Lead carbonate (white)	50-60 grains.

Plasticizer:

Dioctyl-pthalate	4 f. ounces.
c) Tri-cresyl phosphate	1 f. ounce.

NOTE: a) Titanium dioxide, increases the opacity and acts as white pigment.

b) White Lead Carbonate, functions as a heat and color stabilizer.

c) Tri-cresyl phosphate increases elasticity.

Preparation of Vinyl Resin Compound

The dry ingredients are blended and then gradually added in small quantities to the liquid mixture of Di-octyl pthalate and Tri-cresyl phosphate while being thoroughly mixed.

The mixing can be done by hand in a large glass mortar with a pestle, or in a mixing machine of the Kitchen-mixer type.

Commercially, large quantities are mixed in paint mills.

The addition of larger amounts of powder gives a thicker mix and increases the density and firmness when processed. The plasticized mixture has a good shelf life but requires remixing before using. The mixture for processing is colored to produce a suitable monochrome basic shade which will harmonize with the natural tissue background. We endeavor to produce a prostheses of the lightest required shade and depend on surface applied tints to modify the areas which require additional coloring.

The basic monochrome coloring is produced by the addition of discrete amounts of paint pigments which have been thoroughly mixed with small quantities of the plasticized mixture.

Various shades of flesh tints can be developed from a blend of cadmium red, cobalt blue, burnt umber, yellow ochre, etc.

Processing

The plasticized and colored mixture is cured by exposure to moderate heat. The curing temperature varies according to the poly-vinyl-chloride-acetate formulae.

The above formula cures at 130° - 140° C. in either closed or open molds. Closed molds require a longer heat exposure to allow for mold heat stabilization.

Over curing is indicated by a brown or purplish color change of the flash or exposed areas.

The preparation of patterns and molds is similar to other dental processes. Molds may be open or closed and formed of metal or dental stone. Stone molds require a separating medium and we have found Glossy-glaze (Kerr Dental Mfg.Co.) satisfactory for this purpose. Metal molds are treated with a mold release emulsion of silicon grease.

The mixture is painted and poured into a warm mold and on account of its fluid nature it is desirable to have all portions of the mold dependent to the pouring level.

For controlled dry heat curing a laboratory type oven with thermostatic control is essential. Curing can also be done in heated glycerine.

The processed form can be trimmed with scissors also a small amount of modifying can be done with a hot clean wax spatula or other instrument.

Surface tinting is applied with weak solutions of alcohol soluble dyes. These are blended and applied with discretion as they are partially absorbed and have a tendency to migrate and spread throughout the prostheses. Make-up cream and talcum can be used to advantage by the patient.

Adhesives and Retention

Large facial prostheses can be retained in position by adhesives with some additional support from mechanical devices such as eye glasses or dental appliances.

Small prostheses like ears are well retained by adhesives only. We have been using two types of adhesive. One is a latex compound supplied in tubes by the British Drug Houses, under the trade name Selix. This is a well tolerated material with medium adhesive qualities.

Recently we have been using Padgett-Hood dermatome cement for its excellent adhesive qualities. With this cement, prostheses such as ears can be worn for 24 hours or longer.

Summary

1) Vinyl Resins are the most adaptable and acceptable compound which are available for facial prostheses.

2) Restorations of these compounds should be classed as temporary prostheses and provision made for periodic replacement

3) These compounds have a tendency to darken and lose their plasticity; the later change is particularly rapid when they are used in the mouth.

4) Future research on Vinyl Resins may improve the qualities which are desirable for facial prostheses.

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Coloring Materials for Co-Polymer Vinyl-Chloride Acetate Compounds: F.G. Clarke - Industrial and Engineering Chemistry, Vol. 35, p 368. March 1943.

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APPENDIX "C"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH
October 1948

Subject: Tissue Toxicity and Potency of Local Anaesthetics.

Grantee: Dr. E.A. Sellers

Project: DR 19 Amount of Grant: $1,575.00

SUMMARY OF WORK

The work done on this grant up to July 1948 is reported in full in a manuscript entitled "A comparison of nine local anaesthetics" which has been prepared for publication in the Journal of Pharmacology and Experimental Therapeutics. It constitutes, as far as the authors know, the first quantitative comparison of nine important local anaesthetics and develops new principles in performing quantitative comparisons of this kind.

When this work was surveyed it was evident that more work was required on relative potency in conduction-infiltration anaesthesia, and on relative toxicities in tissues. These aspects are being studied further by Dr. J.F. Aikenhead, using retrobulbar block as the method of measuring potency for conduction anaesthesia, and skin toxicity measurements. Another drug, Holocaine, has been added to those under investigation. It would be desirable in the future if a dental graduate could be obtained to continue these studies by a dental technique.

September 20, 1948 J.K.W. Ferguson, M.D.

APPENDIX "G"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH
October 1948

Subject: Tissue Toxicity and Potency of Local Anaesthetics.

Grantee: Dr. E.A. Sellers

Project: DR 19 Amount of Grant: $1,575.00

SUMMARY OF WORK

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When this work was surveyed it was evident that more work was required on relative potency in conduction-infiltration anaesthesia, and on relative toxicities in tissues. These aspects are being studied further by Dr. J.F. Aitkenhead, using retrobulbar block as the method of measuring potency for conduction anaesthesia, and skin toxicity measurements. Another drug, Nolocaine, has been added to those under investigation. It would be desirable in the future if a dental graduate could be obtained to continue these studies by a dental technique.

September 20, 1948 J.K.W. Ferguson, M.D.

APPENDIX "D"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October 1948

Subject: Investigation of Cements for Methacrylate Inlays

Grantee: Dr. A. E. R. Westman

Project: DR 12 Amount of Grant: $5,000 (including DR 21)

SUMMARY OF WORK

The investigations under this grant have been chiefly directed to project DR 21, but with its conclusion in sight and the recent arrival of long-awaited chemicals, it has been possible to begin actual experimental work on DR 12.

The aim of this project is to develop a cement for methacrylate inlays which will be more satisfactory, aesthetically and physically, than the currently-used zinc phosphate cements. The principal objection to the zinc phosphate cements is that their opacity causes a dark line of demarcation between an inlay and the tooth, making it difficult or impossible to conceal the restoration.

At the present time, the use of trihexylamine as a catalyst for the rapid polymerization of methyl methacrylate appears to be promising and worth investigating. It has been reported that trihexylamine was used successfully but only on an experimental scale in Germany to make direct inlays and as a cement for jacket crowns.

A sample of trihexylamine was received here recently and a few experimental tests have been made. They have shown that trihexylamine definitely possesses accelerating properties.

At the present time, attention is being given to the development of a suitable infra-red apparatus which will permit the making of direct inlays. Progress reports on this work will be submitted regularly.

Douglas R. Christie

24 September, 1948.

APPENDIX "D"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Ontario Research Foundation
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4301 - DR 12

Cements for Methacrylate Inlays

In an effort to overcome the disadvantages attending the use of zinc phosphate cements for methacrylate inlays, the development of an acrylic material for direct intra-oral fillings is being considered.

As outlined in previous reports, the use of an accelerator such as trihexylamine is promising. The problem connected with its use is to find some method of heating the acrylic material after it has been packed into the tooth cavity which will enable the dentist to cure the filling rapidly without dangerously overheating a vital tooth.

Preliminary Experiments

In some early investigations, a 250-watt infra-red lamp was used as a source of heat and attempts were made to focus the beam by means of lenses. It was found that the number of optical elements necessary to concentrate the radiations to an area about the size of a tooth absorbed too much heat.

A much more satisfactory arrangement was found in the use of an 8-mm. motion picture projector. The source of illumination which was used consisted of a 500-watt projection lamp with its focussing mirror and condensing lenses. This set-up is more efficient than the infra-red lamp and lenses because it was especially designed for the concentration of radiant energy. This system focusses a very intense irradiation, with considerable infra-red, on a very small area an inch or two away from the lamp. By placing the end of a quartz rod at the focus, the heat could be conducted along the rod to a conveniently removed distance. There would be little ultra-violet radiation in the beam, because most of it would be absorbed by the glass of the lamp and the lenses. On the other hand, glass will transmit infra-red up to 50,000 Å and quartz will transmit up to 70,000 Å

So much heat was available with the projector operating on 110 volts A.C. that it was necessary to operate it through a Variac in order to control the heat.

It is not known with any degree of certainty what temperature a vital tooth can tolerate or for how long. The safest procedure, if heat must be used, is to expose the tooth to as small an increase in temperature as possible and for the shortest time consistent with a satisfactory cure of the inlay. It was assumed that a temperature of approximately 108° F. in the pulp canal might be safe for a few minutes.

Several extracted teeth, which were conditioned in water, were drilled to accommodate a very fine thermocouple in the pulp canal. It was found that if the quartz conductor, 6 mm. in diameter, was placed approximately one millimetre from the inlay or filling and the projector operated on about 55 volts, the internal temperature of the tooth could be held to between 108 and 110° F. Under these conditions the surface of the inlay was heated to approximately 165° F. and about 7½ minutes were required to produce an inlay hard enough to polish.

Technique for a Direct Acrylic Inlay

Satisfactory methods for all classes of cavities have not been investigated fully. Probably the easiest class to experiment with is the Class V or gingival type cavity.

The cavity should be prepared as for a silicate filling, that is, with undercuts and not as for a true inlay without undercuts. The cavity is then filled with inlay wax and the wax carved to the contours of the finished filling or preferably a little in excess. An index is now made with impression compound. With the wax removed from the tooth, the cavity may be packed with the acrylic material.

The filling material consists of a liquid, a 3 per cent solution of trihexylamine in methyl methacrylate monomer, and a powder, methyl methacrylate inlay powder containing 0.5 per cent benzoyl peroxide. A quantity of the powder is placed in a mixing jar, moistened with the liquid and stirred briefly. As soon as the mixture has reached the sticky stage (2 or 3 minutes) a quantity is placed in the cavity, covered with moist cellophane, and tightly compressed with a finger for about one minute. Any excess is trimmed off, an additional small amount

is added, covered with moist cellophane and compressed for at least 3 minutes with the compound index.

Now, the inlay material can be irradiated and at the same time heated as described above. It would be impracticable to use a movie projector in practice, but a suitable source embodying the essential elements of the projector could no doubt be constructed. When the inlay has been cured it may be polished by the usual methods used for acrylic inlays.

Suitability of Direct Inlays

It has not been shown that trihexylamine will or will not cause discoloration to develop. This would no doubt require tests under conditions similar to those which exist in the mouth.

The writer and three volunteers have made tests to determine any oral tissue irritation. No such irritation was found by any of the testers.

Leakage around the periphery of a direct acrylic inlay is a possibility in that the material shrinks slightly on curing. However, there does not appear to be any clinical evidence to support this possibility and direct acrylic inlays have been known for several years. Additional tests will be made here to determine whether leakage does occur.

Other Materials

A new denture repair material, Nuweld, has recently been introduced. A few tests indicate that the liquid component of Nuweld can be used with acrylic inlay powders containing benzoyl peroxide to produce rapid curing without the application of heat. An investigation of this material and its possibilities should receive early attention.

October 18, 1948

Douglas R. Christie
Research Fellow

APPENDIX "E"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry

Grantee: Dr. O.J. Walker and Dr. H.R. MacLean

Project No. DR-9. Amount of Grant: $1100.00

SUMMARY OF WORK

The rate of corrosion of several silver-cobalt alloys in concentrated solutions of such cleaning agents as Polident, SteraKleen, and Hygeol has been determined at 45°C and 50°C. Marked corrosion has been observed only in the cases of Denchrome and Ticonium in Hygeol. Tests were also carried out in which the test pieces consisted of two pieces of alloy soldered together by 18 K gold. In all cases, corrosion was greater than when simple test pieces were used.

Dorothy E. Coggles

PROJECT DR-9

The Corrosion of Dental Alloys by some Common Cleaning Agents

Research Report September 1948.

Drs. O.J. Walker and H.R. McLean with Miss D.E.R. Coggles

An introduction to this work has already been given. In this report some experimental data are provided and some conclusions are made.

I. Dental Alloys

The dental alloys considered are Vitallium, Durallium, Denchrome, and Ticonium, which are mainly chromium - cobalt alloy steels containing small amounts of Vanadium.

II. Cleaning Agents

The cleaning agents used were Hygeol, Polident, and SteraKleen. Hygeol is a 1% solution of sodium hypochlorite. Polident and SteraKleen seem to be made up of sodium and potassium peroxides, percarbonates, and perborates, chlorides, and carbonates. Polident probably contains more percarbonate than perborate, whereas SteraKleen is more perborate than percarbonate.

III. Accelerated Tests

As reported before, an accelerated type of test was used. Squares of the alloys, 1 cm. in cross section were used as test pieces, and these were cleaned before and after each test as follows: first they were washed for 1 minute in concentrated hydrochloric acid, 15 minutes in distilled water, 5 minutes in alcohol, and 5 minutes in ether, and then they were dried for 1 hour in a desiccator before weighing to four decimal places.

The washed and weighed samples were suspended by means of crochet cotton into 500 ml. erlenmeyer flasks containing 250 ml. of corrosion medium. These flasks were fitted with rubber stoppers through which the crochet thread was passed. The method of suspension for samples of Durallium and Denchrome was through holes in the centre of the test pieces, but in the case of Vitallium and Ticonium, which were too hard to bore, the thread passed completely around the samples.

PROJECT DR-9

Saturated solutions of Polident and SteraKleen were used,-they contained 20 gm. per litre. Hygeol was used undiluted. The flasks were suspended in a thermostatically controlled water bath in which the temperature was maintained at 50°C,-excepting in the case of the Hygeol tests on the simple alloys where a lower temperature, 47°C, was used. The high concentration of the corrosion medium and the elevated temperature produce the acceleration of the corrosion reaction.

The test pieces were left in the hot solution for thirty day periods during which the flasks were shaken manually each day in order to provide some motion of the test piece in the corrosion medium.

At the end of the testing period, the samples were withdrawn, cleaned as before, and then weighed. The loss in weight was obtained, and from this and the original weight of sample, the percentage corrosion was calculated.

IV. Experimental Results

Table I - Corrosion in SteraKleen:

	Weight of sample gms.	Loss in weight gms.	Percentage Corrosion	Time for 1 gm. to corrode hrs.
DENCHROME - 741.25 hrs.				
	0.2402	0.0002	0.08	9.3×10^5
	0.2381	0.0002	0.08	9.3×10^5
	0.2264	0.0002	0.09	8.2×10^5
DURALLIUM - 720 hrs.				
	0.6822	0.0004	0.09	8.0×10^5
	0.5736	0.0006	0.10	7.2×10^5
	0.5865	0.0006	0.10	7.2×10^5
	0.3872	0.0003	0.08	9.0×10^5

Table I continued:

VITALLIUM - 696 hrs.			
0.7273	0.0004	0.04	1.7×10^6
1.0114	0.0004	0.04	1.7×10^6
1.0602	0.0002	0.03	2.3×10^6
1.1104	0.0003	0.03	2.3×10^6
TICONIUM - 741.35 hrs.			
0.9224	0.0004	0.04	1.8×10^6
0.7890	0.0004	0.05	1.5×10^6
0.9348	0.0004	0.04	1.8×10^6
0.9561	0.0004	0.04	1.8×10^6

Table II - Corrosion in Polident:

Weight of sample gms.	Loss in weight gms.	Percentage Corrosion	Time for 1 gm. to corrode hrs.
DENCHROME - 741.25 hrs.			
0.2264	0.0003	0.13	5.7×10^5
0.2496	0.0003	0.12	6.2×10^5
0.2107	0.0003	0.14	5.3×10^5
DURALLIUM - 720 hrs.			
0.4582	0.0004	0.09	8.0×10^5
0.4069	0.0004	0.10	7.2×10^5
0.6005	0.0004	0.07	1.0×10^5
0.6810	0.0004	0.06	1.2×10^5

Table II continued:

VITALLIUM - 696 hrs.			
0.7903	0.0002	0.02	3.5×10^5
0.7433	0.0002	0.03	2.3×10^5
1.0074	0.0004	0.02	3.5×10^5
0.8136	0.0004	0.04	1.7×10^5
TICONIUM - 741.35 hrs.			
0.8312	0.0007	0.08	9.3×10^5
0.9370	0.0013	0.14	5.3×10^5
0.8954	0.0010	0.11	6.7×10^5
0.7880	0.0006	0.08	9.3×10^5

Table III - Corrosion in Hygeol:

Weight of sample gms.	Loss in weight gms.	Percentage Corrosion	Time for 1 gm. to corrode hrs.
DENCHROME - 743.5 hrs.			
0.2268	0.0094	4.15	1.8×10^4
0.2336	0.0082	3.51	2.1×10^4
0.2264	0.0098	4.23	1.8×10^4
0.2426	0.0070	2.89	2.6×10^4
DURALLIUM - 718.54 hrs.			
0.5700	0.0038	0.67	1.1×10^5*
0.4361	0.0003	0.07	1.0×10^6
0.6764	0.0003	0.04	1.8×10^6
0.5430	0.0003	0.05	1.4×10^6

* High corrosion due to one jagged edge on sample.

Table II continued:

VITALLIUM - 696 hrs.

0.7903	0.0002	0.02	3.5×10^5
0.7433	0.0002	0.03	5.3×10^5
1.0074	0.0004	0.02	3.5×10^5
0.8136	0.0004	0.04	1.7×10^5

TIDONIUM - 741.35 hrs.

0.8312	0.0007	0.08	9.3×10^5
0.9370	0.0013	0.14	5.3×10^5
0.8954	0.0010	0.11	6.7×10^5
0.7520	0.0006	0.08	9.3×10^5

Table III - Corrosion in Hygeol:

Weight of sample gms.	Loss in weight gms.	Percentage Time for Corrosion gm. to corrode hrs.	
DENCHROME - 743.5 hrs.			
0.2268	0.0094	4.15	1.8×10^4
0.2336	0.0082	3.51	2.1×10^4
0.2564	0.0098	4.29	1.6×10^4
0.2456	0.0070	2.89	2.6×10^4
DURALLIUM - 718.54 hrs.			
0.5700	0.0038	0.67	1.1×10^5*
0.4301	0.0003	0.07	1.0×10^6
0.6764	0.0003	0.04	1.8×10^6
0.5430	0.0003	0.05	1.4×10^6

* High corrosion due to one jagged edge on sample.

Table III continued

VITALLIUM - 718.54 hrs.			
0.8004	0.0020	0.20	3.6×10^5
0.9416	0.0012	0.13	5.5×10^5
1.0132	0.0010	0.12	5.9×10^5
0.7804	0.0010	0.13	5.5×10^5
TICONIUM - 743 hrs.			
0.8240	0.0578	7.02	1.1×10^4
0.9182	0.1042	11.34	0.7×10^4
0.8872	0.0649	7.31	1.0×10^4
0.9302	0.0616	6.62	1.1×10^4
DURALLIUM-DURALLIUM - 336 hrs.			
1.4530	0.0281	1.94	1.7×10^4
1.3894	0.0204	1.47	2.3×10^4
DURALLIUM-VITALLIUM - 336 hrs.			
1.4499	0.0164	1.13	3.0×10^4
1.4244	0.0226	1.59	2.1×10^4
DURALLIUM-DENCHROME - 336 hrs.			
0.8742	0.0603	6.90	4.9×10^3
0.9968	0.0681	6.83	4.9×10^3
DURALLIUM-TICONIUM - 336 hrs.			
1.7190	0.0997	5.80	5.8×10^3
1.7678	0.0824	4.66	7.8×10^3

V. Conclusions:

Corrosion tests on simple samples of the alloys in concentrated solutions of the cleaning agents have been made and the percentage corrosion has been calculated. Experiments have also been conducted with samples of the alloys joined by means of 18 K gold solder. All tests were carried out at a rate accelerated by a high temperature and a high concentration of cleaning agent.

All alloys tested were found to be very resistant to saturated solutions of SteraKleen and Polident. Durallium and Vitallium are resistant to Hygeol but Denchrome and Ticonium are attacked. In the case of the joined samples, all were extensively attacked by Hygeol even though the time of testing was only one half that of the other tests. The accelerated corrosion in the case of the joined samples may be attributed to galvanic effects.

Calculation of the time required for a 1 gram sample of each of the alloys to corrode in each of the cleaning agents gives a comparison of the corrosive effects of a single cleaning agent on a number of alloys and also a comparison of the life of one alloy in a number of cleaning agents. For example, the average time required for 1 gram of Ticonium to corrode completely under constant treatment in Hygeol is 2.1×10^4 hours, or 417 days; for samples of Durallium and Denchrome soldered together, the life is only 4.9×10^3 hours or 204 days.

VI. Proposed Work:

The next series of Tests will be on joined samples in saturated solutions of SteraKleen and Polident. Then, some research will be done using more dilute solutions of all of the cleaning agents.

V. Conclusions:

Corrosion tests on simple samples of the alloys in concentrated solutions of the cleaning agents have been made and the percentage corrosion has been calculated. Experiments have also been conducted with samples of the alloys joined by means of 18 K gold solder. All tests were carried out at a rate accelerated by a high temperature and a high concentration of cleaning agent.

All alloys tested were found to be very resistant to saturated solutions of SterkKlean and Poliboni. Duralium and Vitallium are resistant to Hygeol but Denturone and Ticonium are attacked. In the case of the joined samples, all were extensively attacked by Hygeol even though the time of testing was only one half that of the other tests. The accelerated corrosion in the case of the joined samples may be attributed to galvanic effects.

Calculation of the time required for a 1 gram sample of each of the alloys to corrode in each of the cleaning agents gives a comparison of the corrosive effects of a single cleaning agent on a number of alloys and also a comparison of the life of one alloy in a number of cleaning agents. For example, the average time required for 1 gram of Ticonium to corrode completely under constant treatment in Hygeol is 2.1×10^{5} hours, or 417 days; for samples of Duralium and Denturone soldered together, the life is only 4.3×10^{4} hours or 204 days.

VI. Proposed Work:

The next series of tests will be on joined samples in saturated solutions of SterkKlean and Poliboni. Then, some research will be done using more dilute solutions of all of the cleaning agents.

APPENDIX "F"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October 1948

Subject: In vivo studies of certain fungus-like micro-organisms found in periodontal disease

Grantee: C.H. Best

Project No.: DR 16 Amount of grant: $1500.00

SUMMARY OF WORK

We have been concerned in this study with the development of the microscopic fungus-like organism Leptothrix falciformis, as it is found in surgically produced periodontal pockets in dogs.

Beginning with a sterile pocket, brought about through surgery and the use of cement pack, a controlled study of the bacterial flora of the periodontal pocket can be made.

In a preliminary experiment, we have been able to demonstrate the presence of Leptothrix falciformis in pockets under controlled conditions. In this study, 24 pockets in 6 dogs were produced, sterilized and left untouched for 3 months to become infected. At the end of this period, the pocket depths varied from 8 mm to 2 mm with an average depth of 4.4 mm. Smears of material from the base of the pockets, were made and stained by Giemsa's method and examined. All of the smears were positive for fusospirochetal organisms and in 21 of the 24 pockets, Leptothrix falciformis could be demonstrated.

These findings would indicate that the proper environmental conditions had been produced for the development of the micro-organisms.

Beust and Aisenberg have outlined the life cycle of Leptothrix Falciformis from observations in naturally occurring periodontal pockets. We have observed similar phases in the life cycle of the organism, in smears from surgically produced periodontal pockets. However, we have been unable to follow clearly the development of the fungus in pockets because the

events in the cycle occur so rapidly that only a composite picture of Leptothrix falciformis processes can be obtained at any one time.

It is our intention to study the development of the organism by producing a number of similar sterile pockets and to make smears of material from these after varied intervals so that we will be able to narrow down the times at which the various processes in the life cycle of the fungus do appear.

Our efforts to cultivate the Leptothrix falciformis in artificial media have been continued without success. We are not alone in this respect. Dr. Theodore Rosebury, Professor of Bacteriology, School of Medicine, Columbia University, who has been studying the fuso-spirochetal group of organisms from the standpoint of pathogenicity, has also been unable to culture the fungus. However, he is of the opinion that a joint effort might prove fruitful and has made the suggestion that one of us take advantage of his laboratory facilities for a limited period.

APPENDIX "G"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: An investigation of the mechanism of repair of the supporting tissues of the teeth

Grantee: H.K. Box

Project No.: DR 22 Amount of Grant: $2200.00

INTERIM REPORT

At the present time six phases of the investigation are being carried on, with dogs as experimental animals.

Phase 1.

Purpose - To study the reattachment of the soft tissues to the tooth after surgical detachment and the removal of a section of alveolar bone.

This reattachment has been found to occur frequently, The operation is being repeated at appropriate intervals, so that when sections are made, the repair of the lesion may be studied through all its stages.

Phase 2.

Purpose - To study the uses of cancellous bone chips in the regrowth of alveolar bone which has been surgically removed.

Regrowth of the alveolar bone has been found to occur in a comparatively short time when cancellous bone chips are used. The procedure will be repeated at appropriate intervals as in Phase 1 so that the repair of the lesion may be studied at various stages by histologic section.

Phase 3.

Purpose - To study the rate of epithelial downgrowth that occurs during the formation of an experimentally produced periodontal pocket. This procedure is being repeated at appropriate intervals as in Phase 1.

Phase 4.

Purpose - To study the formation of the epithelial attachment following experimentally produced periodontal pockets.

Again, the procedure will be repeated at appropriate intervals.

Phase 5.

Purpose - To study the reattachment of the soft tissues in experimentally produced periodontal pockets that have been infected for some months.

When periodontal pockets are experimentally formed and allowed to remain undisturbed for some months, it has been found that a pocket flora is developed that is quite similar to the pocket flora in periodontal disease in humans. Calculus is formed in some cases. Further destruction of the surpporting tissues of the teeth, with further deepening of the pocket has been found to occur in some cases. It appears that these pockets are comparable in many ways with the lesions in periodontal disease.

Phase 6.

Purpose - To investigate the origin of the cells concerned in the reattachment of the soft tissues to the tooth.

This is a preliminary study to check the working hypothesis on reattachment that is gradually being developed.

Phase 4.

Purpose - To study the formation of the epithelial attachment following experimentally produced periodontal pockets.

Again, the procedure will be repeated at appropriate intervals.

Phase 5.

Purpose - To study the reattachment of the soft tissues in experimentally produced periodontal pockets that have been infected for some months.

When periodontal pockets are experimentally formed and allowed to remain undisturbed for some months, it has been found that a pocket flora is developed that is quite similar to the pocket flora in periodontal disease in humans. Calculus is formed in some cases. Further destruction of the supporting tissues of the teeth, with further deepening of the pocket has been found to occur in some cases. It appears that these pockets are comparable in many ways with the lesions in periodontal disease.

Phase 6.

Purpose - To investigate the origin of the cells concerned in the reattachment of the soft tissues to the tooth.

This is a preliminary study to check the working hypothesis on reattachment that is gradually being developed.

APPENDIX "H"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: Nitrogen Containing Compounds in Saliva (Sect.1).

Grantee: J.J. Rae (C.T. Clegg)

Project No.: DR 1 Amount of Grant: $ 1760.00

SUMMARY OF WORK

(1) No lysozyme-like substance was observed in caries-immune saliva which would inhibit the growth of l.b.a.

(2) At the request of Dr. Ellis a brief investigation was made of the methods of analysis for cholesterol in saliva. To obtain satisfactory color comparisons with the Lumetron larger samples of the filtrates had to be used than recommended by Krasnow.

(3) After communicating with Dr. Kesel and repeating our experiments we were able to get some inhibition in growth of l.b.a. by filtrates from immune salivas which had been incubated for eight days.

(4) An attempt was made to determine the distribution of nitrogen containing compounds in saliva. In particular the amounts of total nitrogen, protein nitrogen and ammonia were determined before and after centrifuging and treatment with certain protein precipitants.

October 4, 1948. James J. Rae.

APPENDIX "H"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: Salivary Amylase and Dental Caries. (Sect. 2)

Grantee: J.J. Rae (J.T. Dentay)

Project No: DR 1 Amount of Grant: $1760.00

SUMMARY OF WORK

1 July - 30 Sept.

In view of the conflicting results contained in the literature with respect to the relationship between salivary amylase and dental caries it was decided to investigate this relationship more carefully. The major difficulties in assessing any such relationship are:

(1) The collection of a large number of suitable saliva samples.

(2) The chloride concentration in the saliva affects the amylase activity as measured by the usual methods. This factor has often been overlooked by previous workers. To obtain meaningful comparisons of amylase activity and dental caries the amylases should all be determined at the same chloride concentrations. Since this is impractical the amylase values must be adjusted by reference to a graph showing the relationship between chloride concentration and amylase activity. This involves chloride determinations on all salivas used.

The results obtained indicate that there is no relationship between amylase activity of saliva and the incidence of dental caries.

October 4, 1948. James J. Rae.

APPENDIX "H"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

INTERIM REPORT No. 6 on DR 1

The Chemical Mechanism of Dental Caries

PERIOD COVERED - February 8 - September 30, 1948

RESEARCH WORKERS - James J. Rae (Grantee)
Charles T. Clegg
John T. Dentay

INSTITUTION - Department of Chemistry,
University of Toronto

The work done during this period falls into two sections. The first section is concerned with the nitrogen compounds in saliva and the possible existence of a growth inhibitor for lactobacillus acidophilus in caries-immune saliva. This work was done by Mr. Clegg. The second section is concerned with the enzymes phosphatase and amylase in saliva and was done by Mr. Dentay.

This report has two exhibits. Exhibit A is a paper presented by Dr. Rae at the Biochemical Section of the Chemical Institute of Canada Annual Conference in June 1948. Exhibit B is a paper presented for publication in the Journal of Dental Research by J.T. Dentay and J.J. Rae.

SECTION 1

NITROGEN CONTAINING COMPOUNDS IN SALIVA

Feb. 8 - Sept. 30

C.T. Clegg and J.J. Rae

(1) Is There a Lysozyme-like Substance in Immune Saliva?

Flemming and Allison (Br. J. Expt. Path. 3. 252. 1922) observed a bacteriolytic factor to a large non-pathogenic coccus (m. lysodeikticus) present in varying amounts in human body fluids, such as tears, sputum, blood serum and saliva. They called this bacteriolytic factor - lysozyme. Since such a substance would account for the results of Kesel (i.e. an inhibitory substance obtained from immune saliva filtrates) we decided to investigate the existence of a lysozyme-like substance in saliva.

Through the courtesy of Miss Berry, three samples of caries-immune saliva were collected. These were used in the experiments below.

One cc. of immune saliva was added to varying amounts of L.B.A. Culture, previously centrifuged and suspended in 0.85% NaCl solution and the suspension placed in an oven at 37° for 26 hours and 48 hours, as stated. 0.1 cc. of this suspension was then spread on a solid tomato-agar media and the plates counted after 4 days incubation. There were fewer colonies produced with the suspension containing immune saliva.

Following a similar technique another experiment was performed in which an attempt was made to maintain a more constant p^H and the results of this experiment indicated that the immune saliva did not have any inhibitory effect on the number of L.B.A. colonies, produced on the plates.

When the L.B.A. was suspended in a plain beef broth containing no dextrose and the experiment repeated again no inhibitory effect by immune saliva was observed.

Another experiment, in which the L.B.A. was suspended in NaCl solution, showed no inhibition.

In view of the fact that Flemming had shown that egg albumin was a good source of lysozyme, an experiment was performed, in which egg albumin was used in place of immune saliva. The results again indicated no inhibition.

Since we have been unable to observe any inhibitory effect in caries-immune saliva, we have investigated other substance present in a mouth of low L.B.A. count, such as calculus and albamateria. Dr. Kreutzer collected the calculus and albamateria and suspended each in 2 cc. of distilled water. Saliva collected at the same time showed a count of 600. A L.B.A. culture was prepared by growing 4 colonies, selected from an agar plate of a saliva count, for 24 hours in beef broth and dextrose, centrifuged and the beef broth decanted. The L.B.A. was re-suspended in 25 cc. plain beef broth (pH 5.2). 2 cc. of the calculus and water mixture and 1 cc. of the culture were mixed, incubated for 24 hours at 37°. Then 0.1 cc. was plated on a tomato-agar solid medium. Growth was observed after 4 days. There was good growth of L.B.A.

Using the same procedure, the collected albamateria showed a growth of green mold over the entire plate. No L.B.A. was observed on plate. This should be investigated further.

(2) A Method for the Determination of Cholesterol in Saliva

Krasnow has intimated that there is a relationship in cholesterol content of saliva and the incidence of dental caries (J.D.R. 16: 151, 1937 and J. Lab. Clin. Med. 14, 967, 1929).

Four cc. of saliva was mixed with about 1 gm. of calcium sulphate, placed in an oven at 100° for 1 hour. When cool the residue was scraped into an extraction thimble. The thimble was placed in a Soxhlet extractor. In the lower chamber of the Soxhlet 25 cc. of chloroform was placed. The extraction was continued for 4 minutes. The chloroform extract was transferred to a beaker and the apparatus washed with 2 portions of 5 cc. of chloroform. The solution was evaporated just to dryness.

Five cc. of chloroform was added to the dried residue in the beaker. Then 0.1 cc. conc. H_2SO_4 and 2 cc. of acetic anhydride were added. The color was read on the Lumetron colorimeter after 10 minutes using the violet filter. The results are expressed as mg. per 100 cc. by multiplying by 25.

This method seems to be satisfactory but larger samples of the second chloroform extract were required to get satisfactory readings on the Lumetron.

(3) Further Work on Kesel's Inhibition by Ammonium Salts

The work mentioned in our last report with regard to the inhibiting effect of ammonia on the acid production by L.B.A. as observed by Kesel, was continued.

In view of the fact that our early results did not agree with Kesel's observations, we wrote to Dr. Kesel. In his reply he suggested that we were using a too high concentration of glucose, and not enough ammonium salts in our tests. (Since Kesel's paper did not give total volumes, the concentrations of the above were not readily ascertainable.)

Although no inhibition of growth of L.B.A. culture was observed on the addition of an equal volume of 8-day filtrate from zero-count saliva, inhibition was observed when one part of culture-suspension was mixed with 100 parts of the same saliva filtrate. This corresponds with Kesel's results.

(4) Nitrogen-Containing Compounds in Saliva

(i) Protein

Kesel examined all saliva filtrates and found that there was a direct correlation between the amount of ammonia-nitrogen present and the degree of inhibition which the filtrates exerted.

We were desirous of investigating the source of this ammonia-nitrogen and with this end in view we hoped that a study of the protein fraction of saliva would be enlightening.

Two methods were available for protein analysis:

(a) The Classical Kjeldahl method in which the saliva is digested, the ammonia liberated is collected in HCl, (known strength, volume) and titrated against standard NaOH.

(b) Greenberg's Colorimetric Method where the saliva is mixed with 5N NaOH and Folin and Crocalteau's reagent. The

resulting blue color is used as a measure of the tyrosine content of the saliva and is compared in a Dubosq colorimeter with a standard tyrosine solution. The tyrosine value is then multiplied by a suitable factor to give the protein concentration. We found that saliva gave cloudy solutions which interfered with the color comparison. When saliva was mixed with an equal volume of water and centrifuged, a clear liquid resulted which gave good color comparisons.

NOTE: In this method we are neglecting the precipitate formed on centrifuging the diluted salivas. The amount of nitrogen in this precipitate was found to be 17.4 mg. %. If saliva as secreted by the gland is a homogeneous material this precipitate should consist largely of cellular debris and food particles from the mouth. The amount of precipitate obtained in this way varies considerably from person to person.

In an attempt to separate the nitrogen-containing compounds in saliva with protein and non-protein fractions the following procedures were carried out:

(a) The saliva was mixed with an equal volume of water, centrifuged and to the centrifugate was added (i) an equal volume of 10% t.c.a., (ii) an equal volume of 5% acetic acid.

(b) The saliva was mixed with an equal volume of 10% t.c.a.

The results from (a) were 17.4 mg. N in the precipitate obtained on centrifuging, 41.4 mg N left in centrifugate. When the centrifugate was treated with t.c.a. 2/3 of the N remained in the filtrate and 1/3 of the N was precipitated. When acetic was added to the centrifugate the same distribution of N between the filtrate and precipitate was obtained. (b) When an equal volume of 10% t.c.a. was added directly to the saliva the precipitate was found to contain 20.5 mg. %N (39% of total N) and 32.6 mg. %N (61% of total) remained in the filtrate.

From these results it would appear that approximately 2/3 of the nitrogen in saliva is non-protein nitrogen.

In one saliva it was found that no precipitate was obtained on the treating of the centrifugate with an equal volume of t.c.a.

(ii) Ammonia-Nitrogen

10 cc. of saliva was poured into the Kjeldahl apparatus, steam bubbled through it and the distillate was collected in 10 cc. of 0.02 N HCl. After collecting for 15 minutes, the excess of HCl was measured by titrating against 0.02 N Na)H solution. Ammonia-nitrogen ranged from 3.66 to 7.74 mg. %N.

There is a possibility of some hydrolysis of protein during the above treatment. Therefore we will investigate the Permutit method of Folin and Bell (J. Biol. Chem. 29, 329: 1917) as applied to saliva by Karshan (J.D.R. 15, 325: 1935). This work is being continued.

SECTION 2

SALIVARY AMYLASE AND DENTAL CARIES

July 1 - Sept. 30, 1948

J.T. DENTAY and J.J. RAE

Department of Chemistry, University of Toronto

(DR 1)

Due to many contradictory opinions on the subject of salivary amylase the relation of salivary amylase to dental caries was investigated.

1. A complete literature survey on the subject of salivary amylase was made up to and including January 1948.
2. The saliva samples necessary for the experiments were collected from various sources.
3. A standard method was adapted for the determination of the amylolytic activities of the salivas collected.
4. A method for the determination of the chloride ion in such a large number of samples was sought and found.
5. Saliva was dialyzed to remove the chloride ion and a curve drawn showing the relationship between the amount of chloride present and the amylolytic activity of a given amount of the enzyme.

1. The literature on all the salivary enzymes is meager, but amylase had been considered as early as 1875. As most sets of experiments and the papers describing them lacked the necessary controls to make them conclusive, it was necessary to repeat some procedures which had been done by previous workers. Nasse (Arch. ges. Physiol. (Pfluger's) 9, 138 (1875) states that salivary amylase "requires chloride" in order to have any activity at all. R. de Marco (Arch. Physiol. 37, 56-68 (1937)) reaches the conclusion that the "degree of amylolytic activity is a function of the cellular elements in the saliva". He does not take into consideration that by simply changing the chloride ion concentration, the "cellular elements" remaining the same in number, the activity can be changed. G.D. Marshall Day (Dental Cosmos, 76, 683-9 (1934)) reports that the amylolytic

activity of the saliva was on the average, 13% greater in a group of carries-immune persons than in a group of carries susceptible persons. Tower and Crane (J.D.R. 23, 413 (1944)) find the opposite to be true, i.e. Caries active persons have greater amylolytic activity in their saliva than caries immune persons. Rockwood (J. Am. Chem. Soc. 41, 228 (1919)) finds a decrease in activity of the saliva amylase on addition of fluorides. Volker (Tuft's Outlook, 21, No. 2, 1947) agrees with the above statement while McClure (U.S.P.H. Reports: 54, 2165, 1939) finds that fluorides have no effect on amylolytic activity of saliva.

2. The first difficulty encountered was in the collection of saliva samples. The dental College was very helpful in this respect, by letting us take samples from patients in their clinic. The difficulty there was that patients often had chemicals in their mouths or blood from a slight injury to the gums or particles of foreign material. This was circumvented in part by taking the samples before the dentist had started working on the patient. Of the samples thus collected only those were used which had no blood in them and were not obviously polluted in some manner. After the closing of the School the Dental Clinic of the Toronto General Hospital offered to help. Unfortunately these samples could not be used at all since the ailments of the donors would have introduced too many new variables into the experiments. Thanks to Dr. W.R. Franks we were able to collect some samples from cadets in training at the No. 1 A.T.S. of the R.C.A.F. in Toronto. These came from normal young men between the ages of 18 and 26 and were collected with no mechanical or chemical stimulation (resting saliva). After the samples were taken, the condition of the teeth and of the gums of the donors was transcribed from their dental records.

3. To determine the amylase activity a standardized Wohlegemuth procedure for alpha-amylase was used. This consisted of a colorimetric comparison between samples of hydrolysis mixture blown into an iodine solution at 15-30 second intervals and a colorimetric standard obtained by adding 1 ml. of a dextrin solution to the iodine solution. (Sandstedt R.M., Eric Knee, and M.J. Blish, Cer. Chem. 16:712-723 (1939)).

4. Since there were a large number of samples a method for the determination of the chloride ion had to be found which could be quickly performed and which did not take much of our raw material. Schales' and Schales' microvolumetric method met these requirements. In this method the saliva sample of given volume

is titrated with a microburette in the presence of diphenylcarbazone till a purple color is formed and remains. This method was found to give reproducible results, which were checked with the gravimetric silver nitrate method. (J. Biol. Chem. 140, 879, 1941).

5. Since a mixture containing a given amount of enzyme shows different activities at different chloride concentrations, saliva was dialyzed free of chloride and the resulting enzyme solution was permitted to act on starch in the presence of increasing chloride concentrations. The results were plotted. By means of this graph and knowing the chloride concentrations of the individual salivas it will be possible to determine not only the amylase activity of the saliva in question, but also what the activities would be if the chloride concentrations were all equal. Thus there would be a truer basis of comparison than if just the total activities were taken into consideration.

The completion of this work has been interrupted by the necessity of having to construct a new Warburg Fermentometer and the construction of the comparison curves must wait until this machine has been put in operation.

EXHIBIT A

CHEMICAL MECHANISMS INVOLVED IN DENTAL CARIES

(1) Introduction

Dental caries or tooth decay is the most prevalent of all diseases. Very few persons escape its attacks. Dentists spend most of their time in repairs and restorations required by the destructive effects of this disease. In spite of this and in spite of numerous researches on the etiology and progress of caries, the cause of caries has not been completely established and its prevention has not been attained. The results of researches have often been discordant and contradictory.

There are two main theories to account for the breakdown of dental enamel:- (i) the chemico-parasitic theory proposed by Miller in 1883 and (ii) the proteolytic-enzyme theory proposed recently by Gottlieb. The Miller (1) theory assumes that "dental decay is a chemico-parasitical process consisting of two distinctly marked stages:- decalcification or softening of the tissue and then dissolution of the softened residue. The acids that cause decalcification are derived from amylaceous and saccharin substances which have undergone fermentation." Any acid-forming micro-organism may take part in the first stage, any micro-organism possessing peptonizing power in the second stage. In Gottlieb's (2) theory dental caries is regarded as a proteolytic process spreading along and affecting organic structures (lamellae) in the enamel. The specific causitive micro-organism produces a yellow pigment which is present in all stages of dental caries.

I do not propose to discuss the relative merits of these two theories since such a discussion would involve consideration of histological, anatomical and pathological problems beyond the ken of a mere chemist. What I do propose to do is to report on a few chemical findings, relative to the problem of dental caries, which have arisen from our research on this problem over the last three years.

(2) Fluorine and Teeth

Fluorine is qualitatively the most important element associated with dental caries. A recent book edited by Moulton(3) presents the salient features of our knowledge

of this problem to date. An excess intake of fluorine, in the period of formation of enamel, causes unsightly mottled enamel or dental fluorosis whereas an optimum intake (about 1 p.p.m. in water supply) results in a lowered incidence of dental caries. Application of concentrated solutions of fluorides to the enamel seems to reduce the incidence of new caries. The first two of these effects are probably structural the last may be structural, bacteriostatic or antienzymatic. With regard to the structural differences, one of the first questions we considered, was the effect of fluoride on the solubility of powdered tooth enamel in lactic acid. For comparative purposes tricalcium phosphate, which approximates the composition of tooth enamel, was used.

EXPERIMENTAL

A sample of powdered tooth enamel, prepared according to a method described by Manly and Hodge[4], was found to decrease 31.6 mg. in weight when shaken with a buffered 1% lactic acid solution at pH 4.0. The addition of 0.5% sodium fluoride to the lactic acid solution reduced this decrease in weight to 5.6 mg. after 24 hours shaking. No further change in weight was observed after an additional 24 hours shaking. The addition of 0.5% sodium chloride had no affect on the solubility of the enamel. Strangely enough, on analysing the supernatants, it was found that the phosphate values were comparable whether fluoride was present or not.

When tricalcium phosphate was substituted for powdered tooth enamel the results obtained were entirely analogous. Viz:- the addition of sodium fluoride caused a marked decrease in the weight of calcium phosphate dissolved but at the same time the phosphate values in the supernatants were comparable. The calcium value of the supernatant with added fluoride was much lower than the one without added fluoride.

This similarity in the phosphate values and the difference in the calcium suggested the possibility that the calcium phosphate and the tooth enamel dissolved in the lactic acid and then calcium fluoride was precipitated. If this were so any ions which form insoluble calcium salts (e.g. oxalates) or any ions that form insoluble phosphates (e.g. lead) should exert a similar depressing effect on the "apparent solubility" of tooth enamel and tricalcium phosphate in lactic acid. The results of a series of experiments with such salts is shown in

SLIDE I. In some cases (e.g. lead nitrate and silver fluoride) an increase in the weight of residue was obtained showing that the weight of the precipitate exceeded the weight of tooth enamel or tricalcium phosphate dissolved.

Whole teeth suspended in lactic acid at a pH low enough to produce acid decalcification (pH 4.0) with any of the materials added in the concentrations shown were protected from acid attack.

SLIDE I

TABLE I

The effect of various salts on the apparent solubility of tooth enamel and tricalcium phosphate in 1% lactic acid

Material Added	Tooth Enamel		Tricalcium Phosphate		
	mg. Change Weight	P mg. per 10 cc.	mg. Change in Weight	P mg. per 10 cc.	Ca mg. per 10 cc.
1% Lactic Acid	-48 (avg)	5.6 (avg)	-65 (avg)	10 (avg)	28 (avg)
$(NH_4)_2C_2O_4$ 0.01M	-36	7.0	-22	9.8	---
$Pb(NO_3)_2$ 0.05M	+10	0.3	+66	0	11.9
$Ba(NO_3)_2$ 0.05M	-16.2	2.40	-10.2	10.3	27.2
$Ag(NO_3)$ 0.05M	-12.1	2.1	-13.5	9.8	31.4
AgF 0.01M	+8	7.5	+24	4.3	7.9
NaF 0.01M	-25	3.3	-50	5.9	9.0

This series of experiments suggests that the protective effect of fluoride on the acid decalcification of tooth enamel may be due to an interchange of calcium phosphate of tooth enamel by a more resistant material such as calcium fluoride. The decrease in weight of powdered tooth enamel when shaken with lactic acid in the presence of certain inorganic salts (and many such experiments have been reported (5a, 5b) in the literature) is not a measure of the solubility of tooth enamel under these conditions but merely measures of difference in weight of the enamel dissolved and the calcium or phosphate precipitated by the added salt. Further evidence for this suggestion was found when a tooth suspended in a 5% lactic acid solution was protected by added fluoride. The suspending solution after 24 hours was found to contain 4.74 mg. phosphate per 10 ml. but no calcium (6,7).

(3) Saliva and Dental Caries

Of interest to dentists as a clinical tests and of interest to chemists as a possible means of shedding light on the cause of dental caries is the possibility of discovering a distinct chemical difference between saliva from caries-immune individuals and caries-susceptible individuals. The difficulties of finding such a difference are enhanced by the fact that there are all possible gradations from the one extreme (caries-immune) to the other (caries susceptible) with no sharp line of demarcation between them. In addition individuals that can be classed decisively as caries-immune or caries-susceptible are rare. This means that numerous experiments must be performed and the results carefully analysed to see if there is any significant difference between the two groups.

Some of the alleged differences between caries-immune and caries-susceptible saliva as stated in the literature are:-

1- Caries-immune saliva has a lower lactobacillus acidophilus (l.b.a.) count than saliva from caries-susceptible individuals. (Bunting et. al. (8)).

2- Caries-immune saliva converts glucose to acid more slowly than caries-susceptible saliva. This is not unrelated to the above difference since l.b.a. by its action on glucose produces lactic acid. (Fosdick, Hansen et. al.(9) and Snyder (10).

3- The titratable alkalinity, the pH and the carbon dioxide absorption of caries-immune saliva is higher than caries-susceptible saliva. These three factors are not unrelated and the results, particularly when the saliva was obtained without stimulating the flow with paraffin, are not impressive. (Youngburg[11], White and Bunting [12], Karshan[13]).

4- Caries-immune saliva when shaken with calcium phosphate exhibits a greater decrease in calcium concentration and a lower decrease in phosphate concentration than caries-susceptible saliva. (Karshan [14,15]).

5- The amylase activity of caries-immune saliva is higher than that of caries-susceptible saliva (Hubbell[16]).

6- The viscosity of caries-immune saliva is higher than that of caries-susceptible saliva (Willsmore[17]).

7- The ammonia produced on incubation is higher with caries-immune saliva than in caries-susceptible saliva. Related to this it is said that there are ammonium salts in caries-immune saliva which inhibit the growth and acid-production of l.b.a. (Kesel, O'Donnell, Kirch and Wach[18]).

8- Some writers maintain that the lipid phosphorus, the magnesium concentration, the protein content and the cholesterol concentration of caries-immune saliva is less than the corresponding values for caries-susceptible saliva. (Krasnow[19]).

Naturally, in a twenty-minute paper, it would be impossible to discuss all of these factors. I intend to focus your attention on only two of these:- the changes in the calcium and phosphate on shaking with calcium phosphate and the question of the ammonium salts.

(a) Changes in the Concentration of Calcium and Phosphate of Saliva on Shaking with Calcium Phosphate.

Karshan's results intrigued us because of the work we had already done on calcium and phosphate analyses on saliva. Why should caries-immune saliva have 65% of its calcium and 18% of its phosphate removed from its solution by shaking with tricalcium phosphate while caries-susceptible saliva, under apparently the same conditions, had only 43% of the calcium and 44% of the phosphate removed?

EXPERIMENTAL

Preliminary experiments always produced an increase in phosphate on shaking salivas with calcium phosphate. The results of a comparison test with an aqueous solution of calcium nitrate and sodium phosphate, approximating the concentrations of calcium and phosphate found in saliva, are shown in SLIDE II. It will be noted that there is an increase in both calcium and phosphate on shaking with calcium phosphate at a pH of 5.2 but at a pH of 7.4 the phosphate increased but the calcium dropped to a small fraction of its original value. The pH seems to be the deciding factor in the changes that occur in calcium and phosphate values on shaking these solutions with calcium phosphate. (It is interesting to note in passing that calcium phosphate shaken with buffers ranging in pH from 4.5 to 8.4 yields supernatants with a continuous variation in the Ca/P ratio from 1.70 to 0.004. Apparently the CaO and P_2O_5 components of this compound can dissolve independently).

SLIDE II

TABLE IV

The effect of pH on shaking solutions containing calcium and phosphate with tricalcium phosphate

pH		Calcium mg. %		Phosphorus mg. %	
Initial	Final	Initial	Final	Initial	Final
4.52	4.95	8.04	41.1	16.5	36.0
5.20	5.25	8.04	24.4	16.5	34.4
6.65	5.78	8.04	9.3	16.5	30.0
7.40	6.32	8.04	2.2	16.5	25.5
8.50	7.60	8.04	0.84	16.5	27.0

By adjusting the pH of a mixed saliva with buffers before shaking with calcium phosphate we were able to alter at will the changes in the calcium and phosphate produced in the supernatants but in every case the phosphate concentration rose[20]. The results are shown in SLIDE III.

SLIDE III

TABLE V

The effect of pH on the changes in calcium and phosphorus produced by shaking saliva with tricalcium phosphate

pH		Calcium mg. %		Phosphorus mg. %	
Initial	Final	Initial	Final	Initial	Final
3.97	4.75	11.76	35.2	10.6	40.5
5.60	5.38	11.76	11.3	10.6	30.0
7.40	6.30	11.76	2.2	10.6	34.5

We do not regard Karshan's test as a decisive difference between caries-immune and caries-susceptible saliva except in so far as it is an indirect measure of the buffering capacity of the saliva. A well-buffered saliva with a pH slightly over 7 should show a greater increase in calcium than a poorly-buffered saliva on shaking with tricalcium phosphate and such seems to be the case. We are at a loss however, to explain the drop in phosphate values observed by Karshan.

(b) The Effect of Ammonium Salts on Lactobacillus Acidophilus

With regard to the concentration of ammonium salts produced on incubation of saliva, Kesel and his co-workers have reported that as caries-immune saliva stagnates a growth-inhibiting factor for l.b.a. develops. Caries-susceptible saliva under the same conditions develops no such inhibiting factor. They claimed that ammonium salts were the inhibiting factor.

EXPERIMENTAL

To investigate the interference with acid production by ammonium salts, ammonium acetate and sodium acetate (as a control), were added to fresh saliva (l.b.a. source) with added glucose solution and the tubes incubated at 37° for 48 hours. The pH in both tubes dropped from 6.5 to 3.8 indicating no interference with acid production. Increasing the concentration of ammonium salts ten-fold still did not show any inhibition. The addition of beef-broth medium to the mixture before incubation still gave a negative result.

Filtrates prepared, according to Kesel's method, from an eight-day old caries-immune and caries-susceptible saliva showed no difference in their effect on acid production by fresh caries-active saliva and glucose mixtures. This was contrary to the effect observed by Kesel. The possibility that their is a growth-inhibiting factor which might not interfere with acid-production led us to investigate the effect of various ammonium salts on the growth of l.b.a. and in every case no interference with growth was observed either by the salts or by eight-day filtrates prepared by Kesel's method. The ammonium salts may be the by-products or end-product of the activity of a growth-inhibiting substance present in caries-immune saliva. If such were the case the inhibiting factor may be an amino acid, a protein, or a proteolytic enzyme. The presence of such a growth-inhibitor would account for differences in caries-susceptibility of persons on the same diet and for the sudden changes that sometimes occur when individuals change from caries-susceptibility to caries-free and vice versa.

Fleming and Allison[21] in 1922 had observed a bacteriolytic factor in several human body fluids including sputum, and saliva which they called Lysozyme. Attempts to repeat their experiments in the hopes of finding a similar factor for l.b.a. in caries-immune saliva have so far yielded only negative results.

Small amounts of phosphatase are present in saliva but no connection between its amount and the prevalence of dental caries was observed in about 50 Toronto school children[22]. An interesting recent finding is that saliva filtered to remove bacteria contains no phosphatase. The term salivary phosphatase should then be changed to a bacterial phosphatase present in saliva.

The phosphatase content and the characteristics of this enzyme as obtained from l.b.a. are now being investigated. Small amounts of fluorine inhibit the growth of l.b.a. This in all probability due no doubt to its effect on the phosphatase essential for carbohydrate metabolism which accounts in part for the beneficial effect of topically applied fluorine.

One Toronto worker has worked out a method whereby this inhibition of l.b.a. growth by fluorine can be used for the micro-biological determination of this hard-to-analyse element.

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Exhibit B

PHOSPHATASE IN SALIVA

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According to the classical Miller[1] chemico-parasitic theory, dental caries is caused by acids formed in the oral cavity. These acids, for example lactic acid, are most likely degradation products of carbohydrate residues. In all probability they dissolve the enamel of the teeth in certain areas and expose the live dentine to bacterial action. The production of lactic acid may proceed by a scheme, such as the one proposed by Meyerhof[2], for carbohydrate metabolism. This, and almost every other carbohydrate degradation, involves the formation of phosphate-containing intermediates, which require phosphatase for their hydrolysis.

Earlier workers have done some research on phosphatase in human saliva, but came to different conclusions. Since they were interested more in other body fluids, organs, muscles and bones, saliva was treated merely as one of the less important body fluids.

Demuth[3] stated that saliva did contain phosphatase, but in smaller quantities than bile. His hydrolysis experiments took as long as 48 hours. This length of time is certainly not typical of enzyme action and we suggest that he measured rather bacterial than enzyme action. Umeno[4] said that there was no phosphatase in saliva at all, though he found some in the salivary glands. Giri[5] reported that salivary phosphatase was identical with urinary phosphatase, basing this conclusion on a common optimum pH. Glock, Murray and Pincus[6] found saliva to contain varying amounts of phosphatase. They also state that the phosphatase was not entirely due to epithelial cells but also to micro-organisms. Rae[7] showed no relation between salivary phosphatase and dental caries. Smith[8] and Adamson[9] were of the opinion that the phosphatase came solely from desquamated epithelial cells.

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*(This work was financed in part by a grant-in-aid from the National Research Council of Canada.)

These contradictory ideas and findings are due, in part, to the complexity of saliva and to variations in individual salivas. We shall, therefore, try to answer the following question: Is there a salivary phosphatase, or is it merely a phosphatase in saliva due to bacteria, cellular debris or both.

EXPERIMENTAL

Phosphatatic activity was determined by the hydrolyzing action of saliva on an organic phosphate, disodium phenyl phosphate. The temperature at which the hydrolyses were carried out was 37° C. The final subtrate concentration was 1/20 Molar throughout the experiments. The pH values, determined with a Beckman glass electrode pH meter, were varied to find the optimum pH. The buffers used were: Sodium acetate-Acetic acid up to pH 6, Veronal-Hydrochloric acid from pH 6-8 and Veronal-Sodium carbonate from pH 8-10.

The extent of hydrolysis was determined by measuring colorimetrically the amount of free phenol liberated, using Folin and Ciocalteau's[10] method. As a check the amount of phosphate liberated was also determined by Ammon and Hinsburg's[11] adaptation of King's[12] colorimetric method. The colour readings were made on a "Lumetron", a photoelectric colorimeter. The inorganic phosphate already present in saliva was allowed for by adequate controls.

Table I contains some of the average results of experiments conducted as follows: Into a numbered 50 ml. test tube 10 ml. buffer, 2 ml. saliva solution (1:1 mixture of saliva and distilled water) and 2 ml. substrate were pipetted, giving 14 ml. of a solution with the required pH and a 1/20 M concentration of disodium phenyl phosphate. In the control the saliva was first placed into a boiling water-bath for 20 minutes. The saliva used was a mixed unstimulated saliva ("resting") collected from 46 students. The test tube was then placed in a rack mounted on a Warburg apparatus and agitated in the horizontal plane in the water bath thermostated at 37° C. The figures given are the measurements at the end of one hour.

TABLE I

Relation between pH and phosphatic activity of whole saliva.

pH	Mg. phenol liberated per 100 ml. saliva from 0.05 M disodium phenyl phosphate at 37°C. in 1 hour		
	Fresh Saliva	Boiled Saliva	Difference
3.8	2.50	1.35	1.15
5.1	3.58	1.17	2.41
6.0	2.70	1.38	1.32
7.2	2.42	1.38	1.04
8.0	2.25	1.38	0.87
9.0	1.50	1.17	0.33

The optimum pH for the phosphatase in saliva was found to be 5.

Table I shows the figures obtained when whole fresh saliva was used. The supernatant clear liquid from centrifuged saliva liberated only very small amounts of free phenol, (0.002 mg. per ml. of saliva per first hour) when used in the above experiment. Even this trace of phosphatatic activity may have partly been due to the relatively slow rate of centrifuging (2200 r.p.m. for 20 minutes), since saliva filtered through a Seitz filter showed no phosphatatic activity whatsoever. The residue obtained on centrifuging whole saliva showed the same phosphatatic activity as whole saliva under the same conditions (i.e. at pH 5.1 the residue per 100 ml. of saliva liberated in two hours 3.6 mg. phenol.).

In order to be sure that the activity was not lost during the experiments due to filtration or overlong exposure to air, a pork kidney extract was prepared from 0.3 Kg. of fresh pork kidney. The kidney was placed in a Waring Blendor and completely minced up with some distilled water. This mixture was left standing overnight in the refrigerator and filtered next day through 2 cm. of filter-cel on top of a No. 42 Whatman filter paper. A total of 1 litre of solution was obtained of which 0.5 ml. were used per experiment. A boiled

sample of the solution was used as a control. In the first hour slightly more than fifty times the amount of phenol was liberated by this 0.5 ml. sample than by a 1.0 ml. sample of whole saliva. A sample of this solution was passed through a Seitz filter and no decrease in activity was observed.

From these results it appeared that whatever small amount of phosphatase there is in saliva is not secreted by the glands, but gets into the saliva at a later stage. To support this theory an attempt was made to obtain canulated human saliva. This work was done by Dr. J. Kreutzer of the Faculty of Dentistry at this university. The effort was unsuccessful, because of the slow drainage of the glands under normal conditions. The only gland opening large enough to admit a canula was that of the parotid. From the others, sublingual and submaxillary glands, an attempt was made to remove the saliva with an eyedropper as soon as it appeared. The total amount thus obtained amounted to less than 0.5 ml. Further efforts will be made, however, to make such a saliva collection possible.

It was next thought advisable to investigate the micro-organisms present in saliva, isolate them and determine their phosphatase content. The mixed saliva used contained 100,000 lacto-bacillus acidophilus per ml. It was found that the species used by Borden's was the same as the one in human saliva. Therefore a culture of lactobacillus acidophilus in milk was obtained, plated out on tomato juice-agar plates (pH 5) and a pure culture started from the plate in carbohydrate broth. Broth prepared from lean beef with 2% lactose added and buffered with sodium hydroxide and lactic acid was the most successful medium. Of the culture thus obtained samples of 1 ml. were taken containing approximately 100,000 l.b.a. per ml. The control was again a boiled sample. In all other respects the experiments were exactly the same as those with saliva. In this set of experiments no measurable difference could be observed between the phosphatatic activity of the live and the boiled samples. If the phosphatase were intracellular perhaps by breaking the cell walls of the bacillus a measurable amount of phosphatase could be obtained. As no bacterial mill was available, the "cracking" was attempted by alternate freezing and thawing of the culture. Hydrolysis experiments were conducted with the "cracked" lactobacillus acidophilus, but still no appreciable amount of phosphatase could be measured.

DISCUSSION

If phosphatase can pass through a Seitz filter and filtered saliva shows no phosphatatic activity it is reasonable to assume that saliva directly from the glands would contain no phosphatase either. That phosphatase can be filtered was ascertained by passing the pork kidney extract through the same filter and finding no appreciable decrease in activity.

The experiments with lactobacillus acidophilus indicate that only a very small amount of the phosphatase comes from this bacillus. The remainder probably coming to a larger extent from cellular debris and to a smaller extent from other micro-organisms.

Since lactobacillus acidophilus constitutes the bulk of the oral flora it may be assumed that micro-organisms supply only a small amount of the phosphatase.

SUMMARY

1. Since filtered saliva showed no phosphatatic activity and since phosphatase passes unchanged through the filter it may be assumed that saliva as secreted by the glands contains no phosphatase. The phrase "salivary phosphatase" should be changed therefore to the more exact "phosphatase in saliva".

2. Relative to the average population of lactobacillus acidophilus in saliva (100,000 per ml.) only very small amounts of phosphatase are derived from these bacteria.

3. The small amount of phosphatase in saliva is probably derived from cellular debris and food residues, with a lesser contribution by micro-organisms.

Our thanks are due to Miss D.F.J. Berry and Dr. J. Kreutzer of the Faculty of Dentistry. We also wish to express our appreciation to the Borden Co. Ltd. of Toronto for supplying us with lactobacillus acidophilus cultures.

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APPENDIX "I"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: A Study of Methods of Fluorine Analysis to be Applied to Extracted Teeth from People Living in Different Parts of Ontario

Grantee: Dr. M. Doreen Smith

Project No.: DR 13 Amount of Grant: $1,455.00

SUMMARY OF WORK

Work on the microbiological technique for quantitative assay of fluorine has continued. Changes introduced in the synthetic medium increased the rate of acid production, but not the rate of inhibition by fluorine and so were given up. The Snell and Strong medium for Lactobacillus casei, modified only as to pH (adjusted to 5.1 instead of 6.8) has proved as satisfactory as any tried, and is being used for work with teeth.

Teeth are being analysed chemically to check on the microbiological method which still offers difficulties when used for teeth. The phosphate from the dissolved tooth precipitates when neutralized. Attempts are being made to overcome this difficulty. A sample of dissolved tooth distilled and the distillate analysed chemically and microbiologically gave results that checked fairly well: example - 0.0363% fluorine for chemical
and 0.0340% fluorine for microbiological.

During a visit from Dr. H.K. Brown it was agreed that we would endeavour to analyse teeth supplied by him in connection with the surveys he is making. He believes it desirable that the dentin and enamel be analysed separately for fluorine. Accordingly, methods for separating these two fractions are being examined.

October 4, 1948. M. Doreen Smith

APPENDIX "J"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries.

Grantee: Dr. M. Doreen Smith

Project No.: DR 14 - Amount of Grant: $1,500.00

SUMMARY OF WORK

Water samples from Kitchener (low fluorine) and from Stratford (high fluorine) were analysed for three consecutive months, to determine the amount and variation of the fluorine content.

Month	Fluorine content p.p.m. Kitchener	Stratford
February	0.16,0.13,0.12	1.25,1.27
March	0.19,0.16	1.31,1.28
April	0.17,0.17	1.29,1.33

The results justify our choice of these two cities, as they indicate that Stratford water has a fluorine content which is almost optimum, while Kitchener water has a low fluorine content.

Since representative samples of milk are easily obtained, and although a general food it is consumed particularly by the group most affected by fluorine (children), it was chosen for analysis.

Results of Analysis City	Dairy	Fluorine Content p.p.m. 1st week	2nd week	3rd week
Kitchener (April)	Silverwoods	0.03,0.04	0.13	0.11
	Westside	0.03	0.08	0.09
	Maple Grove	0.06	0.12	0.09
Stratford (February)	Avon	0.09	0.16	0.17
	Finnegans	0.14	0.13	0.16
	Silverwoods	0.11	0.11	0.16

Though the fluorine content of milk is low the results indicate that milk from the high water fluorine district has statistically (significant at 1% level) more fluorine than milk from the low water fluorine area. The transference of ingested fluorine to cow's milk has been a matter of controversy and these results are also of interest in this respect.

A recent publication brought to our attention the possibility that atmospheric fluorine may affect the amount of fluorine present in plants. To study this effect spinach was grown in close proximity to a glass factory which was using cryolite and fluorspar in its formula. As a control spinach was grown in the same soil in a location where the fluorine content of the atmosphere was lower. These were both compared with spinach grown in a rural area. Leaves and grass from the first two areas were also analysed for fluorine (August).

Source	Atmospheric F. absorbed by MgO - /5gms. MgO	Fluorine content p.p.m. (dry wt.)		
Glass Factory		Spinach	Leaves	Grass
Glass Factory	425	154,169	86,78	75,78
Control	129	112,117	26,18	30,31
Rural	-	66,32		

It can be seen that atmospheric fluorine affects the fluorine content of vegetation. The importance of further study of the fluorine content of the diet excluding water, is evident.

4 October, 1948.

M. Doreen Smith

APPENDIX "K"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: A study of the use of periodontal packing materials in the prevention and treatment of diseases of the supporting tissues of the teeth

Grantee: H.K. Box, Ph.D., D.D.S.

Project No.: DR 4

This work was carried out in the Banting and Best Department of Medical Research, University of Toronto, by W.J. Linghorne, D.D.S., Research Associate, Department of Physiology, and D.C. O'Connell, M.S.A., Research Assistant, Banting and Best Department of Medical Research.

"K-2"

A STUDY OF THE USE OF PERIODONTAL PACKING MATERIALS IN THE PREVENTION AND TREATMENT OF DISEASES OF THE SUPPORTING TISSUES OF THE TEETH

Final Report

Introduction

During recent years there has been a great increase in the use of periodontal cement packing materials in the treatment of periodontal disease. The purpose of this investigation is to study the therapeutic properties of cement packing materials and their use in periodontia.

Procedure

Periodontal cement packs consist of a powder and liquid which are mixed together to form a paste. In the presence of moisture the paste sets, forming a fairly hard cement. Three formulae, see Appendix 1, were selected as suitable for the various purposes and conditions encountered in periodontal case management. The products differed mainly in the physical character of the mix.

The following in vitro and in vivo studies were carried out.

In Vitro Studies

The materials studied were:- Powders - zinc oxide, tannic acid, asbestos, resin; and liquids - eugenol, thymol and sweet almond oil. The bacteriostatic properties of each were studied singly and in combination using the agar-plate-with-gutter technique as used in penicillin sensivity tests. (See Appendix II) The tests were carried out against Staphylococcus aureus.

The following chart gives the result of the test of the various ingredients in the powders using water as the liquid and asbestos as a binder. The incubation period was 24 hours.

Compound	Zone of inhibition of growth in mm.
Asbestos + H_2O	0
Asbestos + Zinc Oxide + H_2O	1
Asbestos + Resin + H_2O	0
Asbestos + Tannic acid + H_2O	5
Asbestos + Zinc oxide + Tannic acid + H_2O	2

In testing the liquid, water of course was omitted but asbestos was again used as a binder. The following chart gives the results when eugenol alone was used as the liquid; incubation period 24 hours.

Compound	Zone of inhibition of growth in mm.
Asbestos and eugenol	14
Asbestos + Zinc oxide + eugenol	8
Asbestos + Zinc oxide + Resin + Eugenol	21
Asbestos + Zinc oxide + Tannic acid + Eugenol	12
Asbestos + Zinc oxide + Tannic acid + Resin + Eugenol	13

The next chart gives the results using eugenol 75 parts and sweet almond oil 25 parts as the liquid; incubation period 24 hours.

Compound	Zone of inhibition of growth in mm.
Asbestos + liquid	14
Asbestos + Zinc oxide + liquid	21
Asbestos + Zinc oxide + resin + liquid	24
Asbestos + Zinc oxide + tannic acid + liquid	10
Asbestos + Zinc oxide + tannic acid + resin + liquid	12

Asbestos + sweet almond oil gave an inhibition of 5 mm.

The next chart gives the results when eugenol and thymol (98 parts eugenol and 2 parts thymol) were mixed as the liquid; incubation period 24 hours.

Compound	Zone of inhibition of growth in mm.
Asbestos + liquid	22
Asbestos + Zinc oxide + liquid	27
Asbestos + Zinc oxide + resin + liquid	25
Asbestos + Zinc oxide + resin + tannic acid + liquid	12

In all the plates showing inhibition there seemed to be two processes going on at the same time, namely the diffusion of the bacteriostatic agent through the agar and the growth of the organisms. Thus the question arose whether the organisms which had grown beyond the zone of inhibition were alive or dead. They may have grown before the bacteriostatic agent had diffused in the area and then, upon further diffusion, may have been subsequently killed. Accordingly, after two days at room temperature following the initial 24 hours incubation at 37.5°C., five plates and one control were re-inoculated with Staphylococcus aureus and re-incubated. No growth occurred in any portion of any plate except the control plate. Evidently diffusion had continued throughout the whole plate.

In order to ascertain for what length of time the active agent continued to diffuse from the pack, and whether the setting interfered with the bacteriostatic action, the following studies were carried out.

Five grams of pack with eugenol and sweet almond oil and the same amount with eugenol and thymol were placed on swab sticks, (See Appendix IV), and dropped into 5 cc. of beef extract broth.

After one-half hour in the first tube the pack had set and was transferred from tube to tube at intervals.

Tube 1 ... ½ hour
" 2 ... ½ "
" 3 ... 1 "
" 4 ... 1 "
" 5 ... 24 hours

All tubes were then seeded with Staphylococcus aureus and incubated at 37°C. for 24 and 28 hours. No growth occurred in any culture tube.

The next question was whether the result obtained was due to an agent on the surface or to actual diffusion from the core of the pack. Therefore in the next test, after the pack had been allowed to harden in the first tube for ½ hour, it was carried through a series of six washes in one hour, ten minutes in each tube and then carried through two ½-hour tubes, two 1 hour tubes and one 24-hour tube. No growth appeared in any tube after 24 hours incubation. On 72 hours incubation, only the last four of the six wash tubes showed evidence of growth. It appears, then, that time for diffusion is necessary since a 10-minute interval is not always sufficient time to ensure a bacteriostatic concentration.

To determine whether the Staphylococcus aureus had been killed or its growth inhibited only, four tubes of fresh sterile broth were seeded from one of the half-hour tubes in the diffusion series and incubated at 37.5°C. for 48 hours. No growth occurred in any tube indicating that the organisms had been killed.

The next study was carried out to determine how long the pack would continue to diffuse the active agent. It was carried out in duplicate according to the method described above, with the swab stick.

The pack was placed in broth and incubated for 24 hours, then removed and placed in the next broth tube and incubated for 1 hour. Following this, it was transferred to another tube and incubated for another 24 hours. The procedure was continued each day. Day by day the tubes from which the pack had been removed were seeded with Staphylococcus organisms and incubated for 24 hours. Up to the 35th day, no growth occurred in either the 1 hour or the 24 hour tubes. This same pack in broth was set aside in the laboratory for one year, during which time the broth had evaporated to dryness. When the pack was placed in broth for 1 hour, once again sufficient of the bacteriostatic agent had diffused from the pack to prevent the growth of Staphylococcus aureus.

The following studies were made of the bacteriostatic effect of the pack against other organisms. Using the agar-plate-with-well technique (See Appendix III) the effect of the

pack against Pseudomonas aeruginosa, Micrococcus catarrhalis, Staphylococcus aureus, Streptococcus viridans and Streptococcus hemolyticus was determined.

In addition, a comparison of the bacteriostatic effect of the pack with that of pack + sulfathiazole and pack + penicillin was made.

The following chart gives the results of the testing of the pack alone, pack + sulfathiazole and pack + penicillin.

Test materials:

(1) pack

(2) pack + 5% sulfathiazole powder

(3) pack + penicillin (5000 units in 5 grams of pack)

Test Organisms	Zone of Inhibition		
	Pack	Pack + sulfathiazole	Pack + penicillin
Micrococcus catarrhalis	7, 7,	10, 9,	7, 8,
Streptococcus viridans	10,10,	10,10,	11,10,
Streptococcus hemolyticus	7, 7,	7, 8,	10,11,
Staphylococcus aureus	16,17,	8,10,	16,14,
Pseudomonas aeruginosa	2, 1,	1, 2,	1, 2,

In addition to the tests carried out against the above pathogenic bacteria, a similar test was made against Canadida albicans, the micro-organism concerned in thrush. The zone of inhibition produced against C. albicans was 20 mm., indicating that the pack has considerable fungicidal properties.

In Vivo Studies

Studies were carried out to investigate the effect of packing periodontal pockets in humans and dogs.

Procedure

Material taken from the depths of the periodontal pockets was placed on slides, care being taken to prevent maceration of the organisms and it was allowed to dry in air. After drying, the smears were examined under oil, at least 30 fields being considered in thin preparation.

Three methods for removing the material from the pocket were investigated: (1) using a suitably shaped wooden toothpick, (2) a metal probe, and (3) a capillary tube pipette. The first was the method selected and used throughout these experiments. In each case the pocket area was isolated with cotton rolls, excess moisture removed by blast of air, the tooth pick was suitably shaped and lightly scraped along the base of the pocket.

For practical purposes the microscopic findings were divided into three groupings.* Those smears in which no organisms of the fuso-spirochetal group were found were called clinically sterile; those showing one or two organisms per field were called almost clinically sterile; and those smears showing any of the group organisms in fair numbers were called clinically septic. Smears were taken before packing, after the pack had been in place for various lengths of time and after the pocket had been packed several times. Only those series considered to have a bearing on clinical procedure are reported in this paper.

Pockets from 4 to 8 mm. in depth as determined by means of a probe graduated in millimetres, were selected. A number of techniques for applying the pack were tried. Three were selected and used according to the depth and course of the pocket and the nature of the soft tissue wall.

Method I

Where it was possible to retract the soft tissue wall to the base, Method I was used. A mix of Formula 3 was made about the consistency of putty and was introduced a portion at a time, gradually overfilling the pocket. Each portion of pack was sealed to the tooth and to the pack already inserted, avoiding direct pressure on the soft tissues. Finger pressure was used to mould the overfilled portion to the tooth and to seal the pocket. Only half of the mouth was packed at one time and the patient was requested to avoid chewing food where the teeth were packed. The pack was removed

* (See illustrations)

in 24 to 48 hours, at which time the pocket wall was often retracted to the base. Where considered necessary the pocket was repacked, this operation being greatly facilitated by the opening up of the pocket by the preceding pack. The pack was again removed in 24 or 48 hours. In a limited number of cases the pack was allowed to remain in place for 4 to 7 days.

Method II

Where the pocket was narrow, tortuous, deep (over 6 mm.) or where the soft tissue was dense and fibrous, Method II was used. A thin creamy mix of Formula I was made into which shreds of absorbent cotton were mixed. Then with a suitable instrument, this saturated cotton was introduced into the pocket and very lightly tamped until the pocket was three quarters filled. The pocket was then overfilled with a stiffer mix of formula III which was moulded around the tooth using finger pressure to seal the pocket.

Method III

Where it was possible to flow the pack into place using finger pressure and instrument, a mix of Formula II, which would flow under finger pressure, was used.

The purpose in packing was to bring the active agent in the pack into close contact with the bacteria at the base of the pocket. Box, in his paper "Necrotic Gingivitis" pointed out that taking into account the questions of extreme pocket thinness, viscosity of the pocket fluids and the presence of calcific deposits which serve to interfere with great mass movements through constrictions etc., it would appear that convection currents have little bearing on the oxygen distribution in the pocket. Constrictions would slow the rate of penetration of the pocket by diffusion also. Thus in order to permit the diffusion throughout the pocket of the active agent in the pack, either the soft tissue wall must be retracted to the base, or the pocket must be filled to the base with the pack.

The following table gives the results of packing periodontal pockets in humans. Only those cases where the pack remained firmly in place were included. All pockets were found to be clinically septic before packing.

No. of pockets	No. of times packed	Time pack in place	Clinically sterile	Almost sterile	Septic
91	1	24 hrs	64%	14%	22%
42	2	48 hrs	82.5	15	2.5
19	1	4 to 7 days	26	23	47
13	2 or more	4 to 7 days	77	23	0

Leaving the pack in place longer than 24 hours at a time made little difference. When the pack was left longer than 48 hours it was often loosened or displaced.

The following table gives the results of packing experimentally produced periodontal pockets in dogs using Method II.

No. of pockets	No. of times packed	Time pack in place	Clinically sterile	Almost sterile	Septic
24	1	24 hrs	100%	0%	0%

All pockets were clinically septic before packing.

Discussion

The in vivo studies indicate that the cement packs selected are highly effective in combatting the organisms of the periodontal pocket. The in vitro studies show that the pack is bacteriostatic against a number of known pathogenic organisms and that under certain conditions this effect is maintained for a far longer time than is required clinically in pocket therapy. Thus the pocket can be kept clinically sterile for at least a week if desired in treatment.

However, as pointed out before in this paper, in order that the active agent be brought into contact with all the organisms in sufficient concentration for the required time, it appears necessary that either the pocket be packed in such a way that the soft tissue wall is retracted to the base, or that the pocket be filled to the base with the pack. Thus, in the dogs, where conditions were such that the pockets could be packed

to the base, all were found to be clinically sterile in 24 hours. Also, in human periodontal pockets a much higher percentage were found to be clinically sterile following second packing than when only one pack was used. This is to be expected as the opening up of the pocket by the first pack greatly facilitated the second packing.

In order to meet the various requirement in management of periodontal cases, three formulae, varying mainly in the physical characteristics of the mix, are suggested. The mix of Formula I is thick and creamy and might be described as a paint. It is sticky and adheres well to the teeth and mucuous membrane. The mix of Formula II is stiffer and more fibrous but will flow under finger pressure. It is less sticky than that of formula I. The mix of formula III might be compared to the consistency of putty. When applied it will displace the tissues and hold them displaced until setting of the pack occurs. It is not sticky but can be made to adhere to the tooth and to other portions of pack. When set it is softer and less brittle than the mix of either of the other two formulae.

The bacteriostatic effect of the pack appears to be largely due to the eugenol and thymol. The addition of thymol seems to increase the bacteriostatic effect. Sweet almond oil slows the setting time and reduces stickiness. It is omitted in formula I and II as stickiness and quick setting are desirable properties when used by the technique described.

Besides being bacteriostatic, both eugenol and thymol are stimulants and local analgesics. When the pack is applied to tender or painful surfaces, the patient experiences almost immediate relief; also, there is a marked beneficial effect on the tissues observed clinically within 24 hours of the application of the pack.

The pack is fairly insoluble in water but dissolves readily in alcohol. This fact is made use of when cleaning mixing slabs or instruments.

The addition of 5% sulfathiazole or penicillin (5000 units to 5 grams of pack) does not appear to enhance the bacteriostatic effects of the pack against the test organisms.

The in vitro test against Candida albicans, the fungus concerned in thrush, suggests that the pack is an effective fungicide.

Suggestions for use clinically:-

(1) In pocket therapy.

(2) In the treatment of coronitis

(3) Pre-operative to the extraction of periodontally affected teeth.

(4) Pre-operative and post-operative to gingivectomy

(5) On infected surfaces in the mouth.

Conclusions

1. In vitro studies indicate that the periodontal packing material studied is an effective bacteriostatic agent against Staphylococcus aureus, Streptococcus viridans, Streptococcus hemolyticus, Micrococcus catarrhalis.

2. In vivo studies indicate that the pack is an effective agent in pocket therapy.

3. Diffusion of the bacteriostatic agent from the pack into the surrounding media will continue for a far longer time then is required in periodontal case management.

4. The periodontal pack acts as a stimulant and a local analgesic.

5. The addition of 5% sulfathiazole or of penicillin (5000 units to 5 grams of pack) does not seem to increase the bacteriostatic effectiveness of the pack.

6. The pack is an effective fungicide against Candida albicans, the organism concerned in thrush.

Formula I

	Wt. per 100 gms.	
Zinc Oxide		39.2 gms.
Powdered Resin		49.5
Tannic Acid		7.9
Kayolone (Hydrated Aluminium Silicate)		3.4

Liquid

Eugenol	98 parts
Thymol (crystal, readily soluble in eugenol)	2

Formula II

	Wt. per 100 gms.
Zinc oxide	36.9
Powdered Resin	46.5
Tannic Acid	7.4
Kayolone	3.2
Asbestos	5.9

Liquid

Eugenol	98 parts
Thymol	2 parts

Formula III

Powdered Resin	38.5 gms
Tannic Acid	5.0
Zinc Oxide	38.5
Asbestos	18.0

Liquid

Eugenol	75 parts
Sweet almond Oil	25

APPENDIX II

Agar-plate-with-gutter technique for the determination of inhibition produced by cement or paste-like materials against bacteria.

This technique consists of cutting a narrow trough or gutter through the centre of a poured agar plate and then filling this cut with the material being tested.

The test organisms are then streaked up to, but not across the edge of the gutter. After inoculation the plates are incubated at 37°C. for 24 to 48 hours.

The inhibition produced is the distance in millimetres measured from the edge of the trough out to the first pin point colonies growing along the line of inoculation. Beyond the zone of inhibition the test organism should grow well and by so doing provides a control for the test.

By making only narrow streaks quite close together, one organism may be streaked several times on one plate or several organisms may be streaked on the same plate, thereby giving duplication or comparison.

APPENDIX III

Agar-plate-with-well technique for the determination of inhibition produced by cement or paste like materials against a single organism.

This technique consists of cutting a well in the centre of a poured agar plate which has been previously inoculated with the test organism and then filling the well with the material being tested.

Immediately after filling the well, the plate is incubated at 37°C. for 24 to 48 hours. The inhibition produced is the width of the annulus obtained, measured in millimetres (distance from edge of well to bacterial growth just beyond zone of no growth). Beyond the zone of inhibition, the test organism should grow well and thereby provide a control for the test.

Only one organism at a time may be tested by this technique and duplication requires the use of other plates.

APPENDIX IV

Swab stick technique for the determination of the effects of setting and time for diffusion on the bacteriostatic action of cement pack.

This technique consists of making up a batch of pack (5 gms) and placing it around the end of a medium sized swab stick, and then placing it in a culture tube containing 5 cc of a suitable liquid culture medium.

The pack will harden in about one hour in liquid and will continue to diffuse the active ingredient for considerable lengths of time. Once the pack has hardened on the stick it may be transferred from tube to tube as required, making it possible to study rates of diffusion of the active agent from the pack into the surrounding culture medium.

After removal of swab stick with pack, the tubed and treated liquid medium may be inoculated with test organisms and incubated.

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APPENDIX III

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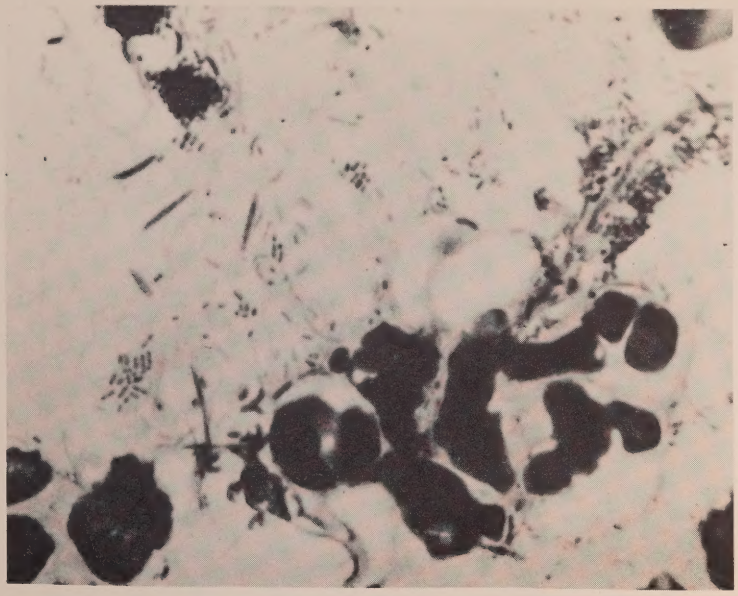
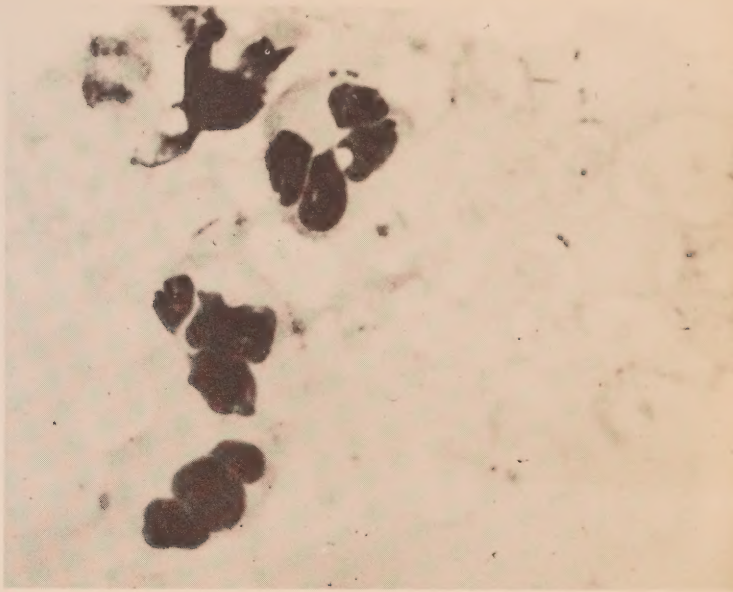
After removal of swab stick with pack, the tubes and treated liquid medium may be inoculated with test organisms and incubated.

1.

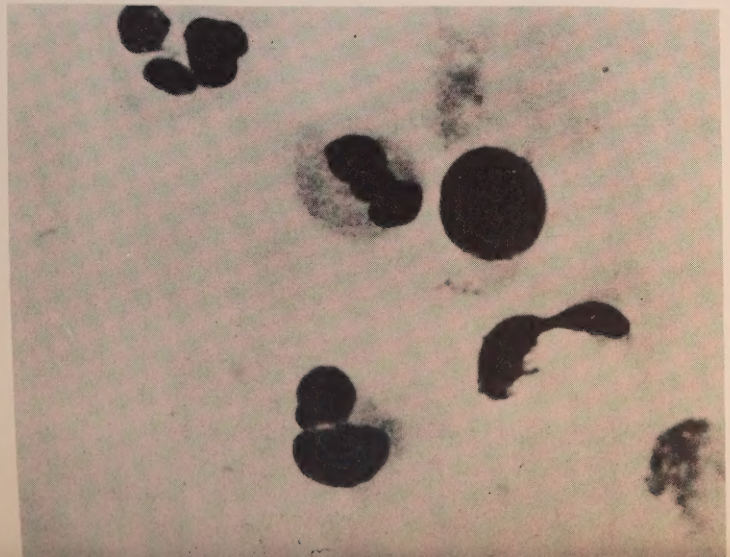


2



"K-19"

3.



Clinical Smears

1. Septic
2. Almost sterile
3. Sterile

APPENDIX "L"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: An Anatomical, Histological and Physiological Study of the Role of the Condyle in Mastication

Grantee: Dr. R.J. Godfrey

Project No.: DR 11 Amount of Grant: $2200.00

SUMMARY OF WORK

The accompanying report may appear to be in greater detail than is necessary for a summary for presentation at this meeting.

It is felt however, that in order to explain the work more thoroughly this detailed account is necessary.

Charles H. Mosen

APPENDIX "F"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: An Anatomical, Histological and Physiological Study of the Role of the Condyle in Mastication

Grantee: Dr. R.J. Godfrey

Project No.: DR 11 Amount of Grant: $2500.00

SUMMARY OF WORK

The accompanying report may appear to be in greater detail than is necessary for a summary for presentation at this meeting.

It is felt however, that in order to explain the work more thoroughly this detailed account is necessary.

Charles H. Mosen

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: An Anatomical, Histological and Physiological Study of the Role of the Condyle in Mastication

Project No.: DR 11

Report No.: 4

Review of Past Studies

In an examination of the experimental rats no gross macroscopic changes in the condyles were noticed when teeth were extracted on one side. Alizarine Red S. experiments were initiated to prove that newly deposited bone will be laid down due to new directions of force. Direction and force alter the structure of bone, causing depositions and resorptions in accordance with the requirements of the bone. New depositions should stain red and resorptions or lack of deposits should not reveal any colouring.

Anatomical studies to determine the cause of the Bennett Movement were suspended pending the arrival of the gnathascope and gnathograph which were to be delivered last year but which have not arrived to date.

Studies confirming the presence of the hinge axis of opening movement in the condyle were also suspended pending the delivery of a cephalometer by the University of Toronto, Faculty of Dentistry.

It was therefore deemed advisable to continue our Alizarine Red S. radiographic and microscopic studies.

Alizarine Red S.

Our original plan was to inject rats extra-peritoneally at intervals. In this way it was believed that rings of growth would be demonstrated. While we were waiting for a better dye (Coleman and Bell) we formed new ideas.

Rats mature at 120 days. We should do our final experiments on rats beyond that age. New growth should be a result of altered function. Since there is no telling when deposition takes place, it would be preferable that the dye be continually available to the tissues rather than intermittantly as by injection. It was decided, therefore, to incorporate the dye in the food.

The Alizarine Red S. was made into a 2% solution and mixed with the food. About 100 cc. of the solution was mixed with 1000 gms. of the stock food.

On Nov. 28, 1947, we clipped the teeth of several rats which were born Sept. 1, 1947. This made it possible to compare the results of clipping a rat at the adolescent stage (88 days) with a mature one. The mature rats should reveal the true story.

We immediately began feeding the rats the Alizarine Red S. mixture.

On Dec. 19, 1947 we sacrificed several rats. We sectioned the condyles of some and defleshed others. These rats were still immature (109 days) but we wished to make some studies at that age as well as at a more advanced age.

In the defleshed skull we were rather astounded by the red colouration over many areas of the cranial and mandibular bones. Closer examination gave more specific information. The lingual surface of the mandible showed far more deposition of red on the functioning side than on the non-functioning side. Directly under the teeth the bone is white on the operated side and red on the side which was untouched. This could be explained by the fact that since function is increased, new deposits are laid down to strengthen the bone. There will be no function near the teeth of the clipped side and therefore no deposition of new bone, there may even be an atrophy.

The possibility of inflamation preventing deposits should be canvassed. It may be a factor.

The same condition prevails on the buccal surface but to a lesser degree.

Clipped teeth render the side more sensitive than extracted teeth because of exposed pulps and sensitive dentine. I believe that with extractions the results would not have been as positive.

Rats sacrificed Jan. 31, 1947 (152 days)

We examined the leg bones for colour. It showed no effects of dye. The head will be defleshed by the time the report is given in Ottawa on Oct. 26, 1948. I intend to bring the colored bones with me.

More rats were operated upon June 9, 1948. These were born in Dec. 1947 and therefore quite mature. We clipped four of these rats and left three for controls, feeding the entire cage the same food.

These animals were sacrificed Oct. 24, 1948. During the summer, particularly a week or two after the operation was performed, I made several visits to the anatomy building where the rats were kept. Each time, Mr. Ross was absent, I was unable to see the food in the rats' cage. I became suspicious that the boys in charge were not attending to the food properly. When I enquired about the food I was told it was to be prepared. At any rate I am unable to say whether the food was properly administered. Upon defleshing the animals negligeable colourations were detected. These were not pronounced in either the operated or unoperated animals.

This experiment will be repeated for verification.

Roentgenographic Studies

The rats' heads were examined roentgenographically. In one film the evidence was quite strong that the functionless side was more radiolucent than the functioning side. There is nothing spectacular about this finding because it is a well established fact that patients become more radiolucent when inactivated by being bed-ridden. The bones become radio-opaque when they become active again. The functionless side should, therefore, become radiolucent.

Even, in some of the rats it requires a stretch of the imagination to establish this fact. One interesting point, however, and not related to this study, should be recorded. In one of the films the central incisor which extends from the anterior part of the mandible under the molars up to the

ramus seemed to have greater radiolucency within the pulp. This may have been due to an infection in the area.

Radiographic evidence may be nullified by the film and other factors. When one of the teachers at our University stated that, perhaps the film did not have the intensity and that we should wait for a new batch, I decided that the comparisons were too minute for accuracy and were not to be relied upon.

Microscopic Studies

It is in this field that we believe important progress has been made. We do not feel unduly optimistic but we have read as much of the literature found and believe that some of our observations are quite original.

Change of Title of Project

At this juncture, we suggest that the title should be changed to read to "An Anatomical, Histological and Physiological Study of the Temporo-Mandibular Joint", or the words "in Function" could be added.

The reason for requesting this change is that the condyle is only one component of the temporo-mandibular joint. The study should consider all the components. The limitation placed upon the subject when the words "in mastication" are used does not permit a complete study because important studies are to be made when the tissues are at rest. There is no intention of leaving the subject, but it is porposed to treat the subject as thoroughly as possible during this term.

Recorded Findings

From a histological standpoint there is not much literature on the temporo-mandibular joint. Of late Robinson, Levy and Becks have contributed some information. None have treated the complete joint from a purely histological standpoint. A survey of the histo-physiological literature of the subject reveals that the knee joint chiefly, and the other joints of the leg have been the chief sources of investigations. Davies has also indicated the atlanto-occipital joint in cattle in his studies.

All these joints are of a different character physiologically, than the temporo-mandibular joint. The latter joint has a sliding motion laterally and antero-posteriorly. This is not true of the other joints investigated. It is natural, therefore, to expect different structures both anatomically and histologically as well as physiologically.

In order that some characteristics of other joints may be compared as well as contrasted, histological sections of the knee of the rat were also made. I am enclosing the photographs of the temporo-mandibular joint. I shall bring other photographs with me that pertain to the subject.

Relevant to the subject at hand, which should have a bearing upon function, little has been written. What has been investigated has been done from a different standpoint. It is necessary to ascertain the normal before we can evaluate abnormal effects. I maintain that the normal has not yet been established histologically. An attempt will be made to collect as much data as possible about the histological picture of the temporo-mandibular joint. The normal will then be differentiated from the abnormal and differences between function and lack of function will perhaps be more easily indicated. Much of the material presented is believed to be original. I have not seen this approach in any of the literature. This does not, of course imply that our observations are correct. Such is not our intentions. Recordings have to be made, however, so that they may be followed through, either by the present investigators or by others who would care to tackle the subject. There is much work to be done by more than one or two persons.

Anatomical-Histological Study of the Lining of the Joint

Gray (1947) states that "the synovial membrane lines the capsular ligament and covers those parts of the bones which are within the capsule, but ceases at the margins of the articular cartilages which it usually overlaps to a slight extent. It gives a covering to all intra-capsular structures, e.g., tendons, ligaments, or articular discs, with certain exceptions. The semilunar cartilages of the knee-joint, which are subjected normally to considerable pressure, have no synovial covering although they are clothed with synovial membrane in the foetus; and an area on the anterior part of the capsular ligament of the hip-joint corresponding to the front of the head of the femur is devoid of synovial lining. In many joints the synovial membrane forms fringe-like processes usually containing small

pads of fat which project into the interior and fill up any irregularities or potential spaces in the joint. The synovial membrane secretes a small quantity of viscid glairy fluid termed synovia. This fluid acts as a lubricant and may help to nourish the articular cartilage. It contains small percentages of salts, albumin, extractives etc., some of which are no doubt contributed by the wearing away of the articular cartilage.

"Histologically the synovial membrane is composed of a delicate, vascular, connective tissue which is covered on its free surface by a layer of flattened cells, resembling a mesothelium. The collagenous groundwork of the tissue is traversed by numerous fine fibres and contains many connective tissue cells of different types. The cell elements of the synovial membrane which, in many ways resembles fibroblasts are migratory and highly phagocytic. They may be present in the synovia and are capable of absorbing micro-organisms and foreign particles injected into the joint. In addition they probably form the cartilagenous debris which must result from ordinary wear and tear."

This is the general picture given, with the possible exception that very few conceed that the synovial membrane has the ability to secrete. The picture is too general, however, and not specific. The temporo-mandibular joint is different in character and structure from all other joints. Moreover, the histological and physiological components are not described in detail.

Anatomical Description of the Temporo-Mandibular Joint of the Rat

The condyle is peculiarly shaped to permit its various movements. Since the antero-posterior movement is more pronounced in rats and in all rodents the condyle is longer in that direction and slides in a prepared groove. Since there are two levels upon which the condyle must travel in an antero-posterior direction--one when the posterior teeth, contract and the anterior teeth overbite, and the other when only the anterior incisors touch, the condyllar joint is constructed to meet this situation. The upper bones accomodate the condyllar movements.

We are more concerned with the soft structures for the present study because we must note that there is a difference between the structures posterior to the condyle and those anterior to it. Both have folds which are called villi. The characteristics of the anterior and posterior villi seem to be different. There is, of course, more movement of this type of tissue on the posterior end than on the anterior end.

An articular disc separates the condyllar articular surface from the upper articular surface. This disc is fibrous in character and is not covered by similar cells to those covering the folds. The surfaces covering the condyle and upper articular surface are also fibro-cartilagenous in character.

Muscles are intimately connected with the disc and the condyle.

Histological and Physiological Description (1) synovial membrane.

The synovial does not completely line the joint. By synovial membrane we refer to the tissue lining the cavity up to the articular surface. Wherever there is pressure or friction there is a fibrous or fibro-cartilagenous tissue.

This tissue resembles epithelium to such an extent that experts can scarcely differentiate. We have shown photographs to various people who have worked upon epithelium and who have examined it with the microscope. They indicate that the tissue has characteristics of epithelium. In the literature, references are found where it was called epithelium by some investigators. Dr. Box, who has examined this tissue and who has studied epithelium for more than thirty years calls this tissue epitheloid in character. Maximow and Bloom state that this tissue was called "mesenchynal epithelium". From the standpoint of embryology the origin of this tissue makes it impossible for it to be epithelium. Be that as it may. Nature has shown time and again that the tissue that is required for a particular function is frequently manufactured. Dr. W. Robert Harris of the Department of Anatomy, University of Toronto states that: "The hyalurono-sulphate of gastric mucosa is found in its mucous secretion. Since its origin here is epithelial, an exception is provided to the rule that this type of muco polysoccharide is found in connective tissue alone."

Dr. Ham of the University of Toronto once stated that if we noticed secretions we should also find epithelium. We believe we notice secretions of a different nature. Why shall we then not expect cells of a different nature.

Kling has reported seeing secreting cells. Davies denies that this is so. He states that what Kling called secreting cells are really mast cells. Examination of Kling's photographs convinces us that he did not describe what we see.

We are submitting photographs of epitheloid tissue (Fig.2) that indicate cells breaking down, cells evacuating and debris which is emptied into the synovial fluid. Close examination of one of the folds shows that it looks and acts as a duct for the product of the cells. This may also be seen in Fig. 3. Fig. 4 shows that cells may break away en masse.

This photograph shows typical epitheloid cells that could be easily mistaken for epithelium.

The joint is completely encapsulated. Its secretory apparatus is therefore not required to manufacture as rapidly as other glandular elements. The word glandular is used deliberately to provoke the thought that the joint could be considered glandular. Glands secrete. There are different types of glands and different types of secretions. An inter-relationship is often found between various glands. This is one of the characteristics. In mumps the mammary glands of the breast, and the testes as well as the parotid gland may be affected. In arthritis several joints including the temporo-mandibular may be affected together. This behaviour may be attributed, in part, to an inter-glandular relationship.

In our five slides the secreting cells have been observed only in the posterior part of the joint. There appears to be no other such reference in the literature. This makes sense if it is true, (and we will have to look at many more sections to confirm it) because there is less motion in this part of the joint. What motion there is, only helps to squeeze the secretions out of the folds.

The villi are so formed that there is more secreting area, a desirable feature, if secretions are necessary. The folds which are like ducts is a feature common to other types of glands.

The villi in the anterior sections do not appear to be secretory but they are characterized by a regular row of fat cells. Fat cells are present under the epitheloid cells of the posterior portion but they do not have the regular row. This appears to have specialized importance which is not too evident yet, unless there is a fatty contribution to the synovial fluid.

The vascularity of the area also makes us suspicious of the presence of secretory glands. The blood supply is certainly not copious in other areas lining the cavity.

Tissues of Interarticular Disc and Articular Surfaces

These are less vascular and are fibro-cartilagenous in character. Robinson denies that mature people possess discs and articular surfaces that are fibro-cartilagenous. He claims they are only fibrous. Our rats appear to have fibro-cartilagenous discs and articular surface. These wear slowly because of their tough character and therefore require slower replacement.

Synovial Fluid

The origin of this fluid is not known. Some of the contents have been recognized. Davies mentions the precipitation of mucin in synovial fluid, but doubts whether mucin concentrate is the sole contributing factor of the viscosity in the joint. Different joints have viscosity of their synovial fluid to different degrees. Voubel suggested that mucin is derived from the connective tissue. This fits in with Wells' idea that there are two chief localities where mucin occurs. (1) as a product of secretion of epithelial cells and (2) from the interstices of connective tissue, especially of tendons. He evidently did not believe that the synovial fluid contained mucin for he said that "the resemblance of synovial fluid to mucin is more physical than chemical".

At the University of Toronto it is believed that "materials now known as muco-polysaccharides were formerly included as mucins and mucoids in the group of glyco-proteins". These are found associated with an unknown protein. There are two types of muco-polysaccharides (1) a non-sulphuric acid-containing type called "hyaluronic acid" and (2) a sulphuric acid-containing type called "hyalurono-sulphate". Dr. Harris believes hyaluronic acid is present in the synovial fluid. Since the above two mucopolysaccharides are found in inter-cellular substance it is reasonable to expect that something breaks it down.

This may be accomplished by enzymes. One such enzyme that acts upon hyaluronic acid is called hyaluronidase. Perhaps the secreting system of other glands is tied up with enzyme activity. There is certainly some agent that causes the mass of cells to become digenerate as in Fig. 4. It could be hyaluronidase or some other enzyme.

Other Factors to be Considered in Studies

(1) Autolysis Cells are known to have self-digestion. The products of this could be factors in affecting the nature of the cells perhaps influenced by other environmental factors like pH.

(2) Hemolysis. There is a hemolytic action upon some of the blood vessels. In our sections the blood-vessels seem to contain blood that has undergone complete hemolysis in some of the vessels surrounding the joint; in others there is no indication of such a process. Fig. 2 shows blood vessel with hemolysis. What causes this hemolysis? Could it be enzyme activity of some sort? Could it be alterations of the pH in some locations? Is it caused by functional disturbances? Mr. Frank Fenton, our technician at the Dental Faculty who has a vast store of knowledge on these and allied subjects through work with Dr. H.K. Box for many years, believes that hemolyses in blood vessels and the differences in pigmentation of the mast cells in different localities of the tissues is directly related to muscle and tendon attachments. Wherever there are certain tensions there are differences in pigmentations.

Mast Cells

It is stated that there are more mast cells in rats than in humans. Mast cells generally group themselves around blood vessels in the connective tissues. Their role is not known. Their chief characteristics are their granules which have an ability to stain electively and metachromatically with basic analine dyes. Willander demonstrated that the heparin content of various organs and tissues bore a direct relationship to their most cell count. If heparin is formed by the metachromatic granules of mast cells as Harris suggests, and heparin is a sulphuric acid - containing muco-polysaccharide, is there a relationship between heparin production and hemolysis?

On the other hand, could not some outside factor cause the alterations in the mast cells which in turn affects the heparin content? Or else could some factor like muscular activity affect an entire area?

Observations of the Knee Joint of the Rat

Bearing all the foregoing in mind, here are some observations made from studying sections of the knee joint:

1. There is pink staining of the mast cells in the outer zones. In nearby tissues they are blue.

2. There is hemolysis of blood in the tissues close to the joint and the mast cells in that location are blue.

3. There is also a hemolitic action upon the bone marrow of the joint bones.

4. The villi have a different arrangement.

5. The fat cells are present but have a different arrangement.

6. There is a mast cell hyperplasia.

7. Lymphacyte forms of cells appear to be the only types that are full developed in the knee joint marrow. All others are actually undergoing complete degeneration with loss of staining and nuclear and cellular structures. We are still investigating this joint from many angles for the purpose of comparison with the temporo-mandibular joint.

Other Observations about the Temporo-Mandibular Joint

We are still examining our sections and the following observations were noted just prior to making this report.

1. In some of the sections the bone marrow shows cells that appear to be undergoing degeneration.

2. The staining seems to be poorer than in other sections.

3. There appears to be a mast cell hyperplasia. The same condition was also noted in the knee joint.

4. Since most cells are plentiful in the surrounding muscles and loose areolar tissues and the accompanying blood vessels, it appears that this mast cell hyperplasia is stimulated by local conditions and that they must have a function locally. Their metachonasia also seems to bear this out. It appears that the metachromatic staining of the mast cells is positive,--the colour is red outside the muscles and blue within muscle tissue bundles.

At this time until further study is made, it is difficult to state definite conclusions.

Observations of the Knee Joint of the Rat

Besides all the foregoing in which there are some observations made from studying sections of the knee joint:

1. There is pink staining of the mast cells in the outer zones. In many tissues they are blue.
2. There is hemolysis of blood in the tissues close to the joint and the mast cells in that location are blue.
3. There is also a hemolitic action upon them bone marrow of the joint bone.
4. The villi have a different arrangement.
5. The fat cells are present but have a different arrangement.
6. There is a mast cell hyperplasia.
7. Lymphocyte forms of cells appear to be the only types that are full developed in the knee joint marrow. All others are actually undergoing complete degeneration with loss of staining and nuclear and cellular structure. We are still investigating this joint from many angles for the purpose of comparison with the temporo-mandibular joint.

Other Observations about the Temporo-Mandibular Joint

We are still examining our sections and the following observations were noted just prior to making this report.

1. In some of the sections the bone marrow shows cells that appear to be undergoing degeneration.
2. The staining seems to be poorer than in other sections.
3. There appears to be a mast cell hyperplasia. The same condition was also noted in the knee joint.
4. Often mast cells are plentiful in the surrounding muscles and loose areolar tissues and the accompanying blood vessels. It appears that this mast cell hyperplasia is stimulated by local conditions and that they must have a function locally. Their metachromasia also seems to bear this out. It appears that the metachromatic staining of the mast cells is positive,--the colour is red outside the muscles and blue within muscle tissue bundles.

At this time until further study is made, it is difficult to state definite conclusions.

APPENDIX "M"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: A study of alveolar O_2 tension and blood oxygen content during N_2O anaesthesia.

Grantee: G.H. Lucas

Project No. DR 2 Amount of Grant: $1200.00

SUMMARY OF WORK

After a desirable plane for dental surgery had been reached with patients during nitrous oxide-oxygen anaesthesia, samples of gas were drawn for analysis at a point beyond the mixing chamber. The analysis was made using a Beckmann Oxygen Analyser.

At the same time as these samples were taken, the oxygen dial setting for percentage oxygen was noted and a sample of expired air from the patient was withdrawn from the nose-piece of the gas mask. The oxygen content of this gas was measured as indicated above. Thus the percentage dial setting for oxygen by the machine was checked against the actual amount of oxygen delivered; the percent of oxygen in inspired and expired gas mixture was compared. Due to the difficulty of securing an adequate number of suitable patients at the University of Toronto Dental Infirmary in the months of May and June, an insufficient number of results have been obtained to justify drawing definite conclusions. As the Infirmary was closed during the summer months, this investigation was temporarily discontinued.

A technique has been developed for withdrawing and analysing suitable samples of gas. The investigation has been resumed since the Infirmary is open and sufficient patients may be secured. It is proposed in the future to measure the oxygen saturation of the blood by use of an oximeter at the same time as the oxygen content of the gas is being measured.

October 7, 1948 Geo.H.W. Lucas

APPENDIX "N"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: Entry of Phosphate and Carbonate Salts into Teeth as shown with the help of Radio-Phosphorus and Radio-Carbon

Grantee: Dr. C.P. Leblond

Project No.: D 23 Amount of Grant: $2200.00

SUMMARY OF WORK

Radioactive phosphorus was injected into newborn and growing rats, the animals being sacrificed from one to 120 hours later. In the newborn rats, the radioactive material was located throughout all bones and teeth. In contrast, in the growing rats (50-60 grams), an appreciable deposition of radio-phosphorus was found mostly in the regions where active formation of bony tissue takes place, that is to say; 1) in long bones, at the epiphyseal plate and periosteum, 2) in the teeth, only in recent dentine and enamel.

C.P. Leblond

October 8, 1948

APPENDIX "A"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: Entry of Phosphate and Carbonate Salts into Teeth as shown with the help of Radio-Phosphorus and Radio-Carbon

Grantee: Dr. G.P. Lebland

Project No.: D 23 Amount of Grant: $2500.00

SUMMARY OF WORK

Radioactive phosphorus was injected into newborn and growing rats, the animals being sacrificed from one to 120 hours later. In the newborn rats, the radioactive material was located throughout all bones and teeth. In contrast, in the growing rats (50-60 grams), an appreciable deposition of radio-phosphorus was found mostly in the regions where active formation of bony tissue takes place, that is to say: 1) in long bones, at the epiphyseal plate and periosteum, 2) in the teeth, only in recent dentine and enamel.

G.P. Lebland

October 8, 1948

APPENDIX "O"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: Improvement of subgingival curettage and surgical techniques used in the treatment of periodontal pockets.

Grantee: Dr. Jules Thebaud

Project No.: DR 20 (Report No. 2)

Amount of Grant: $750.00

Further to my report of February 13th, 1948, the following research tasks have been proceeded with from March 1948 to date:

1. Curetting of the cemental wall -

The technician of the histology laboratory of the Medical Faculty having been unable to prepare suitably a first series of teeth group 1 and group 2, as described in tables 1, 2, 3, 4, 5, and 6 of said report, a second series was attempted unfortunately with the same result. From May to July 1948 the same experiments had to be conducted on other teeth and specimens handed over to another laboratory technician outside the University of Montreal. This second attempt met with better luck and the preparation of the slides are well under way.

11. Curetting of the soft tissue wall -

A type of instrument for this variety of curetting has been outlined but its finished form has not been arrived at, so that experiments could be conducted.

111. Curetting of the base of the pocket -

The final shape has been given to the instrument which will serve for the curetting of the different regions of the mouth. It has undergone clinical experiments, but it has been impossible to establish its effectiveness biologically up to the present time, biopsy having not yet been made on autopsy material (see attached copy of letter to the Dean of the Faculty of Dental Surgery, University of Montreal).

Improvement of surgical techniques

The second part of project DR 20, dealing with improvements to be brought about to surgical techniques used in the treatment of periodontal pockets has received a broader part of our attention. In order to establish the main lines of a technique for gingivo-ectomy, in which resection of pathological gingival tissues will be made and kept to a minimum with adequate measurements, we are already investigating technical specimens.

The enclosed cuts show the instruments pertaining to the researches now being conducted.

J. Thebaud

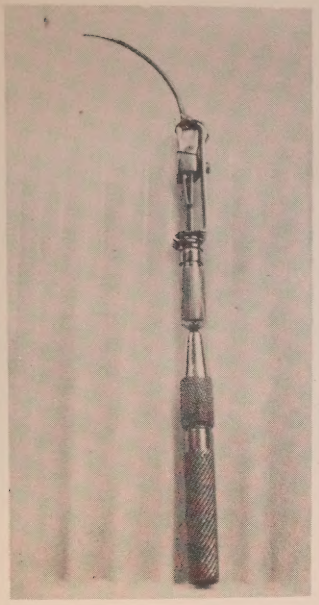


Fig. 1
Special gauge for registrating depths of periopockets(preliminary model)

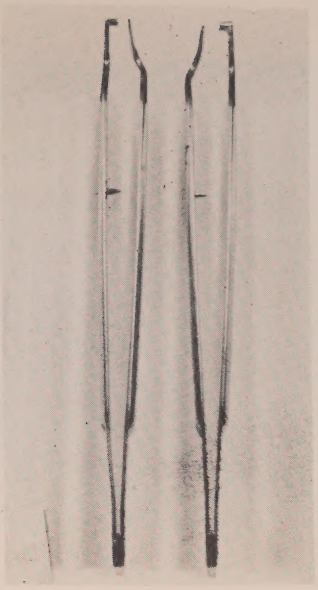


Fig. 2
Calibrated pocket markers

Fig. 3.
Calibrated pocket markers

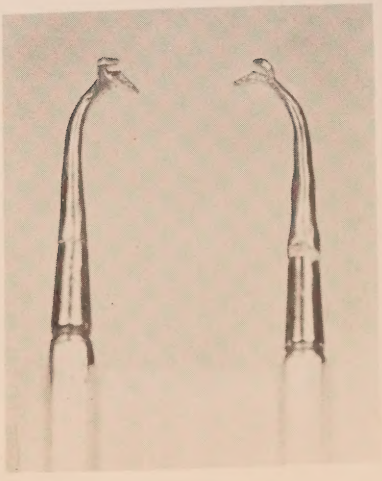


Fig. 4
Pocket indicators
(right and left)

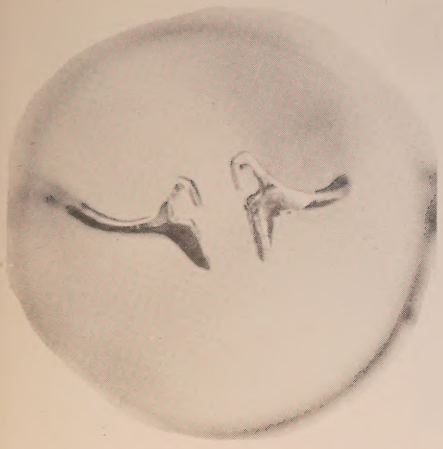


Fig. 5
Pocket indicators

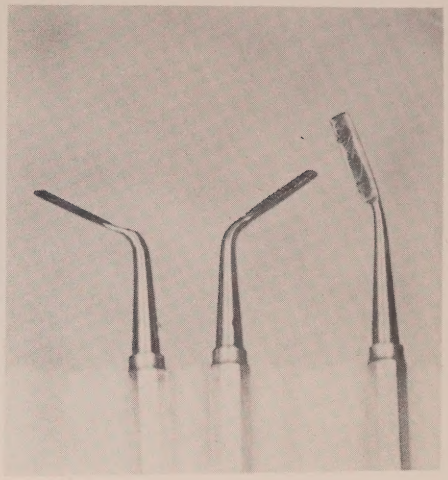


Fig. 6
Gum Lancets (right, left and anterior)

Fig. 7
Gum Lancets (right, left and anterior)

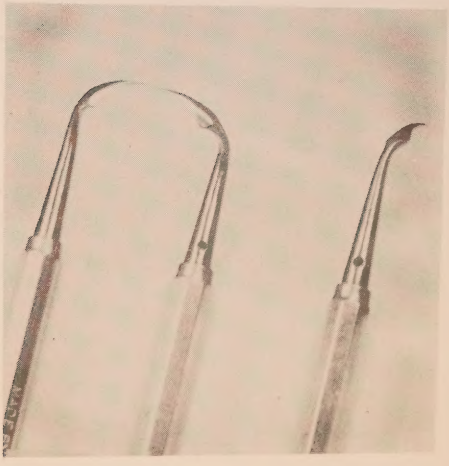


Fig. 8
Interproximal papillae knives (right, left and anterior)

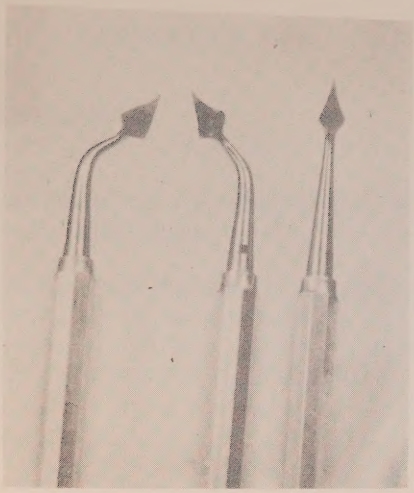


Fig. 9
Tissue-pushers (right, left and anteriors)

Fig. 10
Tissue-pushers (right, left and anteriors)

Fig. 11
Tissue-pushers (right and left)

MEMORANDUM

Du: Dr Jules Thébaud

Au: Dr E. Charron,
Doyen de la Faculté de Chirurgie Dentaire,
Université de Montréal.

Objet: Concours collicité de la Faculté de Chirurgie Dentaire pour la mise en exécution d'un projet de recherches No DR 20, pour compte du Conseil national de recherches d'Ottawa.

Pour donner suite à mon rapport du mois de février 1948 communiqué au Dr. Box, des expériences doivent être faites afin d'essayer de traiter d'une façon spéciale la paroi des culs-de-sac pyorrhéiques formée par les tissus gingivaux.

A cet effet, il est nécessaire:

1°- De répérer l'existence des clapiers pyorrhéiques chez certains patients, préférablement chez ceux qui sont internés dans les salles publiques des hopitaux, dont l'approche de la fin est certaine, et dont les parents responsables permettraient de prélever une portion du maxillaire comprenant deux ou trois dents, dans les deux heures qui suivent la mort.

2°- De pouvoir prélever aussi de la Morgue, pour fins d'autopsie, les mêmes tissues provenant des indigents accidentés, et ceci, au moins deux heures après la mort.

Au sujet de la réalisation de la deuxième partie, du même projet de recherches ayant trait aux améliorations à apporter aux techniques chirurgicales employées en Périodontie, je mets actuellement la dernière main à la fabrication de quelques instruments nouveaux; il faudrait qu'après leur mise au point, que je sois mis en mesure de passer à la phase clinique, en traitant quelques patients.

A cet effet, il est souhaitable et même indispensable que des cas convenables soient fournis par la Faculté Dentaire.

MEMORANDUM

Du: Dr Jules Thébaud

Au: Dr E. Charron,
Doyen de la Faculté de Chirurgie Dentaire,
Université de Montréal.

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2°- De pouvoir prélever aussi de la Morgue, pour fins d'autopsie, les mêmes tissues provenant des indigents sociétaires, et ceci, au moins deux heures après la mort.

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A cet effet, il est souhaitable et même indispensable que des conventions soient fournis par la Faculté Dentaire,

APPENDIX "P"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: Experimental Artificial Production of Dental Caries in Vitro

Authors: H.K. Box, D.D.S., Ph.D., and R.A. Hugill, D.D.S.

Project No.: DR 18

Purpose: To artificially produce a dental caries lesion to meet the microscopical qualifications of the true caries picture.

Scope: The experimental work was carried out on hog and cattle teeth and under three phases or combination of phases.

(a) Enzyme Phase
(b) Acid phase
(c) Acid-Enzyme phase

I EXPERIMENTS CARRIED OUT ON CATTLE TEETH

A
Enzyme Phase:

Lower anterior teeth were completely coated with black compound except for a small "window" on the labial surface. The teeth were placed in 20%, 30% and 40% solutions of pepsin enzyme, pH approximately 4.5. Thymol crystals were added to control or inhibit bacterial activity. The observations were as follows:

1. Observations for 20%, 30% and 40% pepsin enzyme activity were relatively the same.
2. There was very little difference as to the depth of penetration in relation to the concentration or percentage strength of the pepsin enzyme solutions.
3. Before grinding, the exposed window on the labial surface presented a solid, hard, intact surface possessing a dark orangey-brown stain.

APPENDIX "B"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: Experimental Artificial Production of Dental Caries in Vitro

Authors: H.K. Box, D.D.S., Th.D., and R.A. Hugill, D.D.S.

Project No.: DR 18

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Scope: The experimental work was carried out on hog and cattle teeth and under three phases or combination of phases.

(a) Enzyme Phase
(b) Acid phase
(c) Acid-Enzyme phase

I EXPERIMENTS CARRIED OUT ON CATTLE TEETH

A

Enzyme Phase:

4. On rough section, the area below the window showed a marked difference in light opacity to that of normal unaffected enamel. There appeared to be a milkish cup-shaped penetration, three-quarters of the way through the enamel to the dento-enamel junction.
5. On the finished polished section the following observations were made.

(a) Part of the affected enamel beneath the window would chip away during the grinding and polishing process. The broken pieces were not decomposed or broken down, but were relatively hard.

(b) The interpresmatic spaces between the enamel rods appeared to be opened up or partly dissolved or washed out.

(c) At the extremity of the affected enamel below the window was a yellowish-brown pigmented border which will slowly disappear over a period of two to three months.

(d) The affected enamel may or may not contain a light yellowish discoloration.

(e) The dark brownish pigment present in the enamel is removed. This may be removed by the proteolytic activity of the pepsin.

(f) There is evidence of slight proteolytic activity beyond the pigmented border in the interpresmatic spaces.

(g) There is no evidence of cross-striation.

The possible conclusions are as follows:

1. The pepsin enzyme attacked only the organic matrix of the enamel, thus opening up the interpresmatic spaces.
2. The spaces that are microscopically evident may be due to the digestion of the organic enamel sheathes.
3. The activity of the pepsin in spite of its relative acid pH does not cause or produce any microscopical evidence of decalcification i.e. no cross-striation was present.

B
Acid Phase:

Lower anterior teeth were completely covered with black compound except for a small window on the labial surface. The teeth were placed in a .5% solution of lactic acid, pH 3.5. Thymol crystals were added to control bacterial activity.

The observations were as follows:

1. Before grinding the section, the window on the labial surface of the tooth presented an area of soft milkish-white material which could be readily washed out. A definite cup-shaped depression was formed in the tooth.

2. On grinding, a considerable amount of the tooth structure underlying the window was lost.
3. The decalcified structure remaining at the base of the window when held against the light, possessed a greyish-crystalline transparency or translucency.
4. There was marked evidence of cross-striation, destruction of interpresmatic substance and somewhat of a translucency to the enamel.
5. The interod spaces did not appear to be as clearly defined as in sections reacted on by the enzyme.
6. There was no evidence whatsoever of pigmentation.

The possible conclusions are as follows:

1. Acid decalcifies and removes the enamel rods.
2. In partial decalcification, acid produces in the enamel -
   (a) cross-striation
   (b) interpresmatic destruction
   (c) translucency of the enamel
3. Acids are evidently not responsible for pigmentation.

C

Acid-Enzyme Phase:

Lower anterior teeth were completely coated with black compound except for a "window" on the labial surface. The teeth were placed in a 30% solution of pepsin enzyme and a 1% solution of lactic acid, pH 3.5. Thymol crystals were added to control bacterial activity.

The observations were as follows:

1. Previous to sectioning the window remained intact, and no depression was produced in the surface of the tooth. However, the surface structure on the window was not as hard as the enamel affected by the pepsin enzyme alone, but harder than the enamel affected by the acid alone.
2. On grinding, some of the enamel structure below window was lost.
3. The remaining enamel structure at the base of the window produced a combination of microscopical pictures produced by the action of acids and enzymes separately.

4. Cross-striation, destruction of interpresmatic substance, areas of translucency in advance of the grossly affected areas of the enamel, and a pigmented band--especially at the border of the microscopically apparent destructive process in the enamel, were produced by the acid and enzyme in combination.

The possible conclusions are:

1. Both acid and enzyme are required to produce a picture simulating the characteristic features of a true carious lesion.

II. EXPERIMENTS CARRIED OUT ON HOGS' TEETH

A
Enzyme Phase:

Anterior teeth were completely coated with black compound except for a small "window" on the labial surface. The teeth were placed in 20%, 30%, and 40% solutions of pepsin enzyme, pH 4.5. Thymol crystals were added to control bacterial activity.

The observations were as follows:

1. On the labial surface of the enamel over the window, a cup-shaped depression was produced and the window appeared to be considerably pigmented of an orangey-brown colour.
2. The action of the pepsin in most cases had penetrated through the enamel into the dentin.
3. Some of the enamel structure was lost during the grinding and sectioning of the tooth.
4. The remaining enamel structure was pigmented yellowish orange over the window. The interod spaces were very definitely washed out.
5. A milkish-grey opacity was apparent in the affected enamel when held against the light.
6. The remaining enamel structure was of a slightly yellowish pigmented discoloration.
7. The dentinal tubules appeared to be enlarged or swollen in the affected area, although the tubule structure did not appear to be impaired.
8. The affected dentin possessed a slight yellowish pigmentation.
9. No cross-striation of enamel rods was evident.

The possible conclusions and explanation are as follows:

1. Some of the findings on the affects of pepsin enzyme on hogs' teeth are contrary to the findings produced by pepsin enzyme on cattle teeth. For example, the affected enamel in the window remained intact in the sectioned cattle teeth and no depression was produced into the enamel surface, whereas in hogs' teeth a depression was produced in the enamel surface, and part of the enamel structure was lost during grinding and sectioning. This may be explained on the theory, that the inorganic content of the hog's tooth is considerably lower than in cattle and human teeth, and conversely, the organic content much higher. Thus when considerable amounts of organic content of the enamel structure in the hog's tooth was digested or removed by the action of the enzyme, there was not sufficient body or strength in the remaining inorganic content of the enamel rods and matrix to hold the enamel rods essentially intact.

2. The pepsin enzyme appears to have produced:

   (a) pigmentation of the enamel
   (b) digestion of the interod spaces in the enamel
   (c) swelling of the dentinal tubules
   (d) slight pigmentation of the dentin

B
Acid Phase:

Anterior teeth were completely coated with black compound except for a small "window" on the labial surface. The teeth were placed in a .5% solution of lactic acid, pH 3.5. Thymol crystals were added to control bacterial activity.

The observations were as follows:

1. A large percentage of the enamel structure of the crowns was lost, with a definite cupping out of the enamel over the window, with structure loss extending into the dentin matrix.
2. Remaining enamel structure possessed a brownish-grey opacity when held against the light.
3. The dentin structure below the window possessed a very dark brownish grey pigmentation, and was not of a hard texture but very rubbery and flexible.

4. Microscopically, the remaining enamel is quite homogeneous with very little definite structure remaining visible.
5. There was indefiniteness as to the outline of the dentinal tubules which had the appearance of a matrix slightly decalcified.

The possible conclusions are as follows:

1. The acid will completely decalcify and break down the enamel structure.
2. There was insufficient enamel structure remaining to establish the presence of cross-striation, i.e. the process of acid destruction had passed the phase of cross-striation of acid decalcification.

C
Acid-Enzyme Phase:

Anterior teeth were completely coated with black compound except for a small "window" on the labial surface. The teeth were placed in a 30% solution of pepsin enzyme and a 1% solution of lactic acid, pH 3.5. Thymol crystals were added to control bacterial activity.

The observations were as follows:

1. There was considerable loss of structure over the window on the labial surface of the tooth, extending down to the dentin matrix.
2. The remaining enamel structure possessed a slight orangey-yellow pigmentation along with evidence of cross-striation.
3. The dentin showed definite signs of loss of structure, i.e. a homogeneous and an outward band of affected dentin in which the dentinal tubules appeared to be swollen and enlarged.
4. There was also a definite orangey-brown pigmentation at the base of the window in the dentin matrix especially in the homogeneous structure of the dentin.

The possible conclusions are the following:

1. The acid and the enzyme combine to form many phases characteristic of true caries
   (a) cross-striation the enamel
   (b) yellowish pigmentation of the enamel
   (c) swelling of the dentinal tubules and a homogeneous appearance
   (d) orangey-brown pigmentation in the dentin

APPENDIX "Q"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of the dental arches.

Grantee: Norma Ford Walker

Project No.: DR 15 Amount of Grant: $3,000.

Summary of Work

During the past eight months (since the report of February 1948 was submitted) the interest of the parents and children concerned with this study has been well sustained. Series of 3 casts have now been made and measured for 55 children, series of 2 casts for 92 children and 15 additional children have recently been included in the study. The objective at present is to take six impressions of each child.

A marked improvement has been made in the method of accurate measurement of the growth of the jaws. Upon the advice of Dr. Richardson, of the Department of Physics, University of Toronto, a measuring microscope is now being used, with a vernier scale, accurate to one hundredth of a millimetre. This method has several advantages over the former method of using an upright camera and measuring the enlarged image of the casts.

It is still premature to attempt to give any analysis of the data, but in addition to the original problem of comparing the patterns of eruption of the deciduous teeth with the rates of growth of the dental arches, special attention is also being paid to the relation of increased susceptibility to caries and the "spring-up" and "falling-off" periods in the developing jaw.

APPENDIX "G"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1948

Subject: A comparison of the patterns of eruption of the deciduous teeth in men with rates of growth of the dental arches.

Grantee: Norma Ford Walker

Project No.: DR 15 Amount of Grant: $3,000.

Summary of Work

During the past eight months (since the report of February 1948 was submitted) the interest of the parents and children concerned with this study has been well sustained. Series of 3 casts have now been made and measured for 35 children, series of 2 casts for 92 children and 15 additional children have recently been included in the study. The objective at present is to take six impressions of each child.

A marked improvement has been made in the method of accurate measurement of the growth of the jaws. Upon the advice of Dr. Richardson, of the Department of Physics, University of Toronto, a measuring microscope is now being used, with a vernier scale, accurate to one hundredth of a millimetre. This method has several advantages over the former method of using an upright camera and measuring the enlarged image of the casts.

It is still premature to attempt to give any analysis of the data, but in addition to the original problem of comparing the patterns of eruption of the deciduous teeth with the rates of growth of the dental arches, special attention is also being paid to the relation of increased susceptibility to caries and the "spring-up" and "falling-off" periods in the developing jaw.

AN IMPROVED METHOD FOR PROCESSING ACRYLIC DENTURES*

by D. R. CHRISTIE†

Introduction

DURING the last two years, investigations on several problems connected with the compression moulding of methyl methacrylate denture base material have been carried out at the Ontario Research Foundation. This work was started at the request of the Canadian Dental Corps and has been supported in large part by grants from the National Research Council through the Associate Committee on Dental Research.

The program was concerned chiefly with the development of a rapid method for processing dentures with the elimination of porosity. Attention was also directed to the problems of polymerization shrinkage, trial packing, polishing by chemical methods and repairs without distortion.

Various aspects of these problems will be dealt with in succeeding sections of this paper.

Physical Properties of Methyl Methacrylate

Monomeric methyl methacrylate is a colourless liquid whose chemical formula is $CH_2=C(CH_3)COOCH_3$. Its specific gravity at 20° C is 0.945 and its boiling point at 760mm. pressure is 100.3° C. Methyl methacrylate polymer is a clear, colourless solid whose specific gravity at 20° C. is 1.19.

In making dentures, it is convenient to prepare a mixture of one part of monomer to three parts by volume of polymer powder which consists of fine granules or spheres. This mixture is packed into a mould under pressure and the monomeric component is converted to the polymerized form by heat.

The completely polymerized denture base material has a softening point of approximately 185° F. Its water solubility is less than 0.1 per cent.

It will be seen from the figures above that there is a volumetric change on polymerization of the monomer of about 21 per cent. However, since the monomer represents only a fraction of the mixture of monomer and polymer powder used to make a denture, this value will be reduced accordingly. Values in the literature[1, 10, 12, 14] for the linear polymerization shrinkage of denture base material are about 0.35 to 0.5 per cent. These figures are less than the theoretical values based on volumetric shrinkage and may be caused by the restraining influences of a complex mould shape.

Polymerized methyl methacrylate denture base material absorbs water to the extent of approximately one per cent of its weight[14]. In terms of dimensional changes, it is reported[1, 10, 12, 14] that this water sorption may cause a linear expansion across the

* This project was financed in large part by a grant from the National Research Council through the Associate Committee on Dental Research.
† Research Fellow, Ontario Research Foundation, Toronto, Ontario.

ridges of a denture of 0.3 to 0.5 per cent. This expansion nearly compensates for the polymerization shrinkage so that the net change in linear dimension (the difference between polymerization shrinkage and expansion due to water sorption) is very small and of little practical importance.

Methyl methacrylate has been chosen as a suitable denture base material because it has good colour stability, it is strong, hard, and light in weight, because it can be suitably pigmented to give an excellent life-like appearance, because it remains relatively clean in the mouth and also because it can be easily moulded at low pressures and cured at reasonably low temperatures. It is not a completely satisfactory denture base material, as this paper will make clear in subsequent sections, but if used in a suitable manner, highly efficient results can be expected.

Mixing of Monomer and Polymer

As previously stated, the monomer (liquid) and polymer (powder) are mixed in the ratio of about 1:3 by volume. Manufacturers' directions are usually sent out with all materials specifying the quantities to be used. In practice these quantities can be varied within small limits and it is best to use the minimum amount of liquid for two reasons. Because methyl methacrylate has a large volumetric shrinkage on polymerization, the smaller the quantity of monomer in the mixture, the smaller the shrinkage will be. Also, a great excess of monomer will cause a type of porosity which is characterized by large localized pits or bubbles in the finished denture base.

It is good practice to add the powder to the liquid. In this way, the globules of polymer are more likely to be evenly wetted by the monomer. Some stirring is necessary to ensure that the liquid and the pigment on the powder particles are evenly distributed through the mixture. The monomer is a solvent for the powder and the mix passes through an initial stage when it resembles wet sand, to a sticky stage and then to a doughy consistency when it is ready for trial-packing.

The time required for these changes to take place varies with temperature but is usually 20 to 30 minutes. If the powder and liquid are placed in a cold jar and put in a refrigerator, the mix requires many hours to reach a workable stage and may be used several days after that.

In this work the commercially available powder and liquid forms of Lucitone were used, for no other reasons than that it is readily available and is a representative acrylic denture base material.

Trial-Packing[3]

It would not be feasible to eliminate trial-packing by calculating the quantity of resin to use on the basis of the ratio of the weights of the resin and the wax model. The model is usually a combination of wax and base plate material in varying amounts and frequently contains voids which would upset any calculations.

With some experience the number of flask closures can be reduced to a minimum. If the first trial-pack is made with enough of the resin mixture, the mould will be filled and a flash will be produced. In addition, the resin will be compressed enough so that no defects will result on processing. The flash can be trimmed off, a slight excess added and the dental flask closed in a spring-compress ready for curing. If small channels are cut in the land of the investment and extended through corresponding channels in the walls of the flask, the excess of resin can flow into them without danger of forcing the halves of the flask apart, thus "opening the bite", and this excess will also compensate to some extent for the shrinkage on curing.

Description of the Polymerization Process

Methyl methacrylate polymerizes readily under the influence of heat, light and catalysts such as benzoyl peroxide. The reaction is exothermic and

eventually becomes auto-catalytic in that as the heat of polymerization is developed, the reaction proceeds more rapidly. Eventually the polymerization goes so rapidly that a considerable evolution of heat results. Since the plaster investment and the denture base material itself are very poor heat conductors, there is a strong tendency for very high localized temperatures to develop in the resin.

For example, when a powder-liquid mixture of methyl methacylate denture base material is cured rapidly, the following usually occurs. The temperature of the resin increases gradually from its initial temperature to approximately 185° F. where suddenly the temperature increases very rapidly and may rise as high as 280° F. It falls again just as quickly but, in this short space of perhaps a minute or two, considerable damage may result to the denture. Fig. 1 is a temperature-time graph of a typical rapid polymerization, the temperatures being measured by thermo-couples inserted in the resin.

To control this reaction, some means must be provided for the heat of polymerization to be conducted away as fast as it develops. In the usual methods of denture making, the resin temperature can only be prevented from rising too high by keeping the ambient temperature as low as possible until polymerization is nearly complete. After a considerable degree of polymerization has occurred, it is safe to raise the ambient temperature without damaging the restoration.

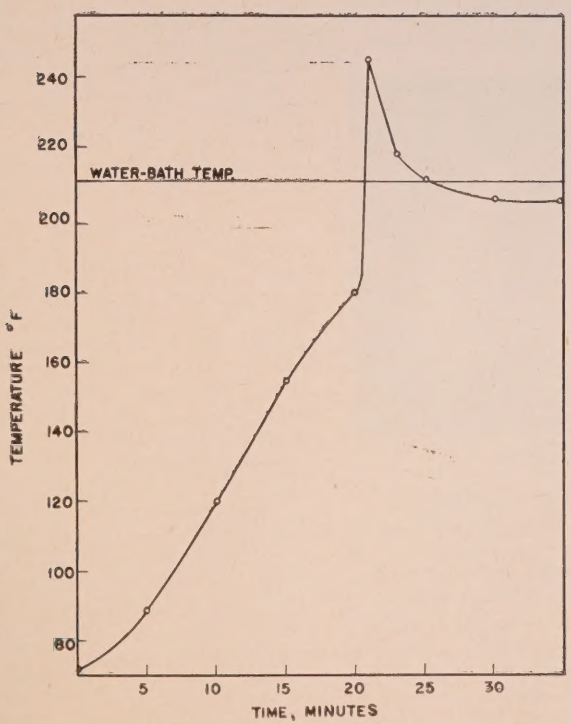

FIGURE 1.

Most curing techniques are adapted to this end. They make use of relatively low water-bath temperatures for considerable lengths of time followed by higher temperatures.

Porosity

One of the most commonly occurring defects in processed acrylic dentures is porosity. It has received the attention of numerous investigators[2, 9, 14, 16] since the acrylics first came into general use and at least five causes have been presented for its occurrence. Two of these will be dealt with briefly.

(1) *Insufficient Pressure*

It has been reported[4, 14] that the bubbles occurring in this type of porosity are partial vacuums. It can be avoided by ensuring that sufficient material is present in the mould so that a positive pressure can be applied during the cure. Fig. 2 shows a photograph of a denture which was deliberately made with insufficient material in the mould to illustrate this kind of porosity.

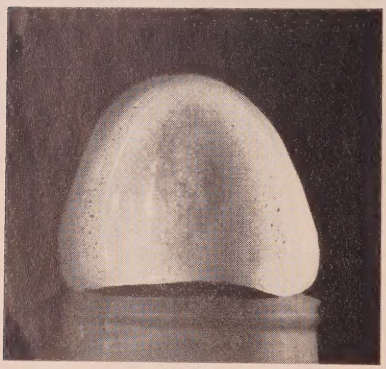

FIGURE 2.

(2) *Volatilization of the Monomer*

This is the most common cause of porosity. If the temperature of the resin greatly exceeds the boiling point of the monomer (100.3° C.) while it is still soft enough to flow, bubbles will form. This almost always happens if the cure is too rapid. It is the result of the exothermic reaction and the poor thermal conductivity of the plastic itself and the plaster and stone investment. When porosity occurs, it is more apt to do so in areas where the greatest bulk of resin exists or in the positions where the resin is nearest to the centre of the investment.

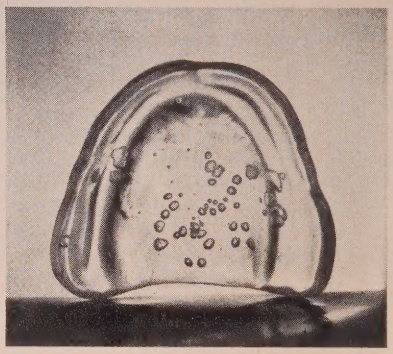

FIGURE 3.

Fig. 3 illustrates this type of porosity. This edentulous case was processed by immersing the dental flask in a boiling water-bath. Even though provision was made to conduct away the heat of polymerization by means of thermoducts (this will be explained more fully in a later section), porosity resulted.

Internal Strains[11]

It is virtually impossible to mould a denture without some internal strains in it, because the investment materials (plaster and stone), the teeth (porcelain) and the denture base material all have different coefficients of thermal expansion. Strains resulting from these properties cannot be removed by an annealing process.

However, all strains are not important from the point of view of subsequent distortion during use. Only those which relieve themselves and cause the denture to warp are significant.

If temperature differences occur during polymerization, local strains may quite easily be formed because of differences in degree of polymerization in various parts of the resin. Similarly, temperature differentials should be

avoided in cooling a processed denture, therefore slow cooling is advisable.

It has been the object of the curing method which was developed at the Ontario Research Foundation, and which will be outlined later, to minimize strains by controlling the temperature of polymerization by eliminating local temperature effects and also by controlling the cooling rate.

Observations of Strains

There are four methods of observing strains in a denture.

(1) *Heating in Water*

As the denture base material is heated in water and approaches its softening point, strains are relieved and warpage or distortion occurs. Investigations have shown that dentures will withstand temperatures up to 185° F., for 5 minutes at least, without showing any appreciable distortion. Above this temperature distortion becomes increasingly pronounced until at 212° F. it is quite severe. This does not mean that the dentures are unusable, only that in use they should never be immersed in very hot water.

(2) *Observation in Polarized Light*

The use of polarized light is confined to clear dentures where the strain patterns can be seen. Strains around porcelain teeth in a transparent denture are easily seen by this method. When plastic teeth are used, strains are very greatly reduced. This would appear to be an argument for the use of plastic teeth.

(3) *Dimensional Changes in Service*

There are several references in the dental literature [8, 13, 15] to the fact that dentures with internal strains may change in dimensions over a considerable period of time. In the work on this subject there was no evidence that such changes do occur: on the whole, the problem is not serious because, in practice, distortion occurs rather infrequently. Although little is definitely known about this subject, it is evident that internal strains may be one of several contributing factors.

In view of the possibility that these strains may cause distortion, it is well to guard against them where possible. One way, as Tylman and Peyton [16] state, is to avoid "extreme practices in the processing technique". The elimination of extreme local concentrations of heat in the resin during polymerization can be accomplished by using the method described in this paper.

This third method of observing strains, that is, by noting any dimensional changes in the denture under service conditions, is therefore indirect. The absence of dimensional changes does not indicate a strain-free denture, but only that the strains, if present, are not serious or that the service conditions were not such as to cause the strains to be relieved.

When made by the new technique, a denture 18 months old at body temperature (99° F.) still showed excellent adaptation to its cast and to an index of the occlusal and incisal surfaces of its teeth.

(4) *Immersion in solvents*

Active strains, particularly those around porcelain teeth, are revealed by immersion in a solvent (even in ethyl alcohol, which is a poor solvent for methyl methacrylate) in the form of crazing.

In the literature there is a reference to polishing dentures by means of solvent vapours [7]. At the same time and independently the same idea was considered at the Ontario Research Foundation. However, in the few attempts which were made to polish dentures by solvent vapours, for example, with ethyl acetate, the result was always an extensive crazing of the entire denture surfaces and particularly those areas around the teeth. When plastic teeth were used, these teeth themselves were severely crazed.

Since solvents have such damaging effects on processed dentures, it is advisable to keep solvents, in any form, away from them.

Study of the Polymerization Reaction

Numerous experiments were made to

learn as much as possible about the polymerization reaction. In general, it was found that the more rapid the cure, the higher was the peak temperature. It became increasingly evident that to produce satisfactory dentures it would be necessary to control this exothermic reaction by reducing or eliminating the sudden evolution of heat.

(1) *Catalysts*

The rate of polymerization of methyl methacrylate is increased by heat, by light and peroxide catalysts. Conversely, the rate is reduced or polymerization even inhibited by anti-oxidants such as hydroquinone.

The use of hydroquinone to slow down the reaction by adding this compound to the monomer used in the powder-liquid mixture was investigated. It was found ineffective because although the time to reach the "kick-over" point was prolonged, the peak temperature was not reduced.

(2) *Use of Metal Powder in the Investment*

The thermal conductivity of the investment can be increased by incorporating in it a finely-divided metal powder such as aluminium. This will serve to conduct away the heat of polymerization more quickly than plaster alone.

These facts were confirmed by studies which indicated that when polymerization occurred the peak temperature was reduced. It was also found possible to speed up the rate of curing and reduce porosity. However, the use of aluminium powder had two disadvantages: (1) a very fine aluminium powder produced a weak investment and (2) a smooth mould could not be made when a relatively coarse (30 mesh) powder was used.

(3) *Thermoducts*

In some early experiments samples of denture base material were cured in a heated hydraulic press. The steel moulds were fitted with thermometer wells which were very close to the resin but no temperature increases were detected on polymerization. This showed that the polymerization could be controlled by conducting away the heat of reaction as rapidly as it was produced.

Thermoducts had been advocated and used to some extent in the past in the tooth-half of an investment for purposes of thermal conductivity and it was decided to follow this line in developing a suitable rapid processing method. The use of only one thermoduct as suggested was found to be inadequate. An arrangement which gave very satisfactory results is shown in Fig. 4 which is a photograph of a cross-section of a dental flask with two thermoducts in the investment. It is believed that thermoducts have not been used previously in artificial stone casts to control the heat of polymerization.

FIGURE 4.

(4) *Heating Cycle*

In preliminary experiments it was noted that the peak temperature could be reduced somewhat by cooling the flask and the denture material just before the rapid evolution of heat took place. Additional support for the idea that a suitable cure could be worked out on this basis was found in Kelly's[5, 6] curing technique which involved cooling of the denture base material as one of its steps.

Results indicate that if the denture material is heated to incipient rapid polymerization, cooled and then completely polymerized, any peak temperature which may occur is not liable to cause porosity as it would normally do in a rapid curing method.

An Improved Method With Thermoducts

Using two thermoducts in the mould,

the following curing cycle was developed. The dental flask is immersed in water at 120° F. and is heated over a period of 15 minutes to about 170° F. The water in the heating bath is then replaced with cold tap-water and the heating continued at the same rate up to 212° F. This will require about 25 to 30 minutes. At this time the curing may be stopped and the flask allowed to bench-cool for 20 minutes. When the flask has been further cooled in cold water for about 5 minutes it may be opened and the denture completed.

Figs. 5 and 6 are presented to show the effects of the thermoducts. Figure 5 shows the thermal effects, recorded by thermocouples in clear denture base material, when only one thermoduct is used. Polymerization proceeds uniformly through the mass of the resin until at 185° F. the temperature in the thick region of the flange increases rapidly to 237° F. This peak did not produce any porosity, but it was desired to eliminate such local thermal effects on the theory that they would cause local differences in degree of polymerization of the resin and would therefore be liable to produce undesirable internal strains.

Fig. 6 shows a similar case when an additional thermoduct is present in the artificial stone cast. In this instance, no peak occurs and all parts of the resin have cured at the same rate. In both examples, the polymerization was completed in less than one hour, effecting a considerable saving in processing time.

Transverse Strength

The test for transverse strength in the Tentative American Dental Associa-

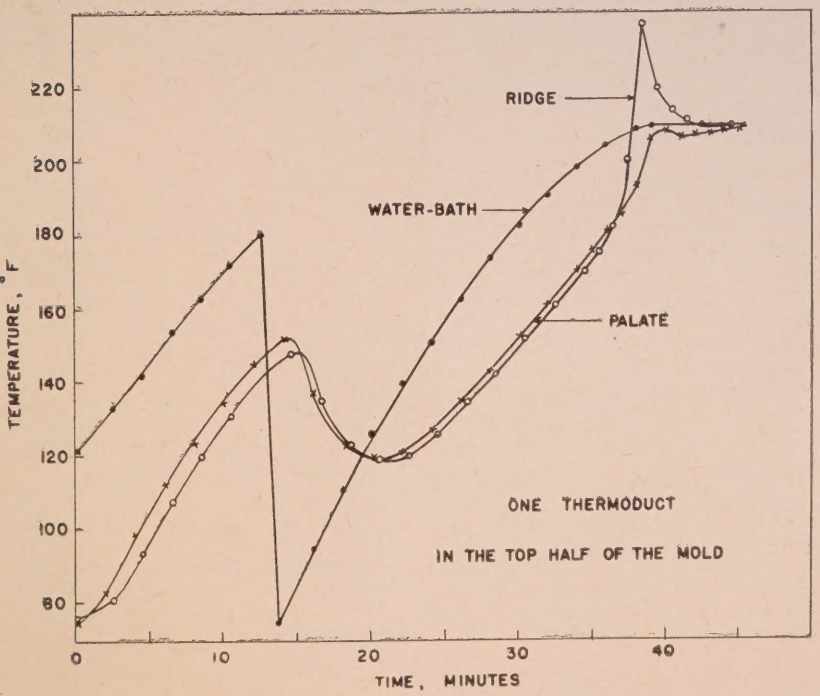

FIGURE 5.

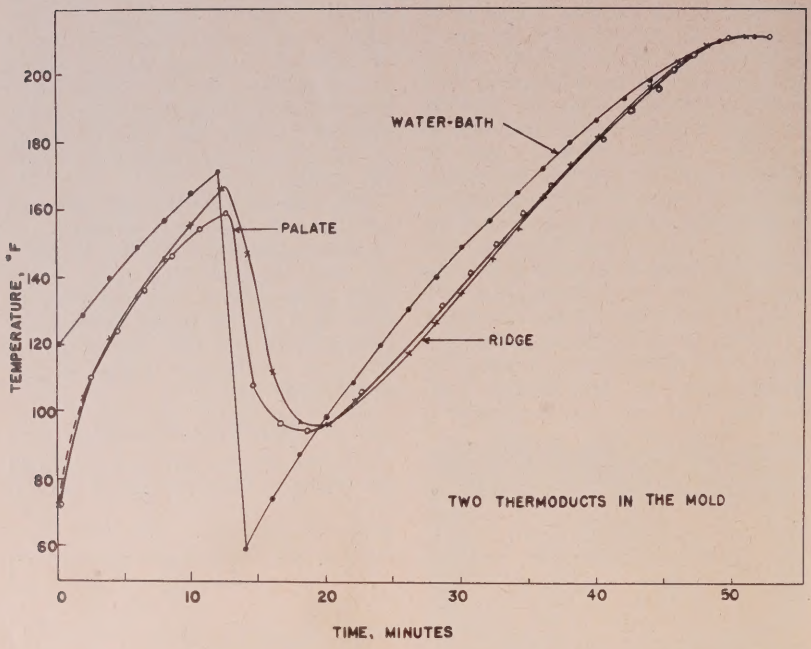

FIGURE 6.

tion Specification No. 12 was used to ascertain if the method outlined above would produce a satisfactorily cured denture base material. This test ensures that the denture is properly cured and that it is tough without being too flexible or too brittle. Since Lucitone is accepted by the A. D. A. as a satisfactory denture base material when properly used, the transverse strength test can be used to check the suitability of a particular curing method.

The specification requires that the denture base material specimens (2.50 x 10.0 x 65 mm. in dimensions) shall show a deflection of less than 2.6 mm. at a load of 4000 grams, a deflection between 3 and 8 mm. at 6000 grams and the maximum load shall be at least 6000 grams.

Table I shows the results of tests made on material cured by controlled methods.

Cure 1 is a controlled method with heating discontinued when the water-bath reached 212° F. It passes the specification limits and therefore the curing method is satisfactory. Cure 2 is also a thermally controlled technique but with the heating prolonged at 212° F. for an additional one-half hour. A comparison of these two cures shows that there is no important advantage to be gained by prolonged heating at 212° F. with the exception of a slightly higher maximum strength.

The technique used by the Canadian Dental Corps was found to be a satisfactory curing method on the basis of transverse strength but it required one hour and 45 minutes to complete and peak temperatures of well over 220° F. commonly occurred.

Practical Cases

The method using thermoducts was worked out on a research scale. All

TABLE I

Transverse Strengths by Thermally Controlled Methods

Load	Average Deflection Cure No. 1	Average Deflection Cure No. 2	A.D.A. Specification No. 12 Requirement
Grams	mm.	mm.	mm.
2000	.30	.38	
3000	1.09	1.18	
4000	2.05	2.10	Less than 2.6
5000	3.15	3.20	
6000	4.57	4.60	3.0 to 8.0
7000	7.40	6.90	
	Average Maximum Load 7000 grams	Average Maximum Load 7400 grams	
Required Maximum Load			6000 grams

dentures were made on a standard-sized cast, so that only one size of thermoduct was required for all cases. In the making of practical dentures for patients, these ideal conditions would not be present and, in addition, there would conceivably be unexpected minor difficulties to be overcome. A practical research program was therefore carried out at the University of Toronto and a number of dentures made for actual service.

Thermoducts

The necessary thermoducts for insertion in the stone casts were designed by taking measurements of a number of model casts in a collection at the Dental College of the University of Toronto. The important dimensions such as depth of vault, distance between ridges, etc. were measured and a good indication obtained of the average dimensions. With the aid of these measurements, several thermoduct models were made for both upper and lower dentures and then cast in bronze. The bases of the thermoducts were polished flat so that they would make good contact with the bottoms of the dental flasks and thus provide the maximum thermal conductivity.

Thermoducts for lower dentures should be made high enough to ensure that, when properly inserted in the denture cast and invested in the lower half of a dental flask, the land of the investment is approximately horizontal and level with the rim of the flask. Several brass plates were designed to be attached to the bottom of the thermoducts to permit the adjustment of the thermoducts to various desired heights. In addition, some of the plates were made with their top and bottom surfaces at slight angles to each other so that the denture could be invested at an angle which would facilitate deflasking. These details are shown in Figure 7. In practice, it was found

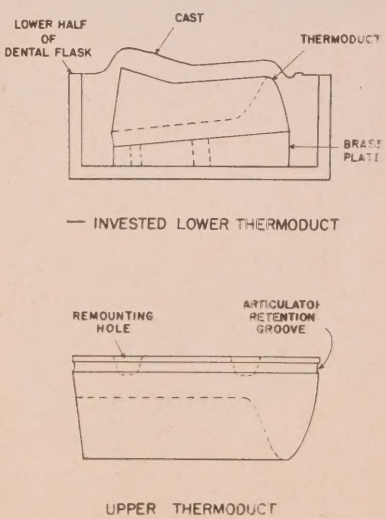

FIGURE 7.

that one plate of the correct height and/or pitch was adequate for most cases.

Fig. 7 also shows a thermoduct for an upper denture. These had to be modified by cutting a trough or undercut near the base on all sides, so that the cast and thermoduct could be mounted securely on an articulator bow by means of the plaster used for that purpose. Also, for purposes of remounting to check the articulation of the teeth of a finished denture, two holes can be counter-sunk in the bases of the thermoducts. These holes are not necessary if a different method of remounting, making use of an occlusal index, is used.

It was found that it is an easy and accurate step to position the thermoducts in the artificial stone cast if the impression was not boxed. It is common practice for many commercial dental laboratories not to box their impressions. However, in view of the fact that boxing ensures that the periphery of the impression is preserved, this safer procedure was followed in pouring the casts for the practical dentures.

Figs. 8 and 9 show respectively photographs of a lower thermoduct and a spacing plate and an upper thermoduct.

Full Dentures

In the limited time available, five full upper dentures and two full lowers

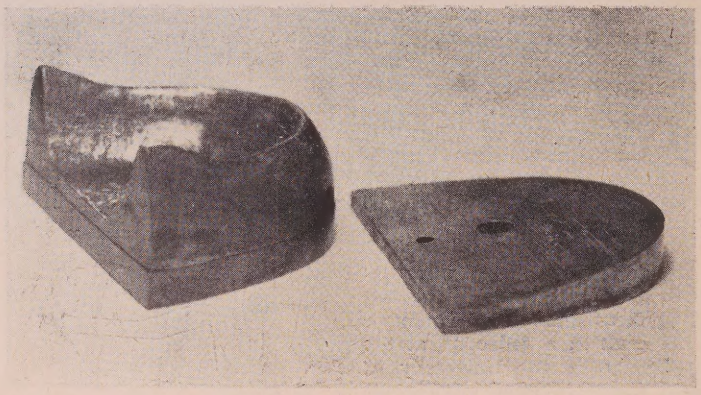

FIGURE 8.

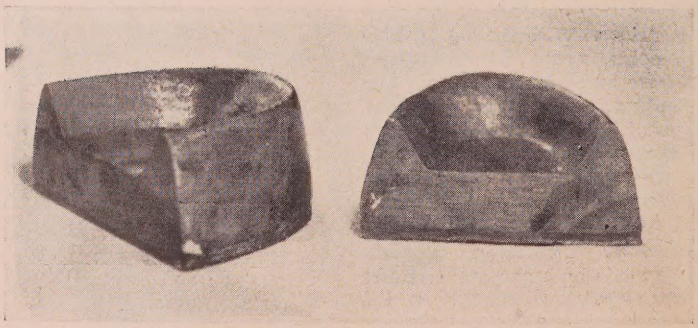

FIGURE 9.

were completed by thermally-controlled methods as well as one upper and three lowers by the method used at the Dental College of the University of Toronto. This latter method requires heating at 160° F. for one hour, then raising the temperature to 212° F. and heating at this point for an additional one-half hour. Where a complete set of dentures was being made for a patient, one was processed by a controlled method and the other by the Dental College method in order to compare the techniques and the results in each case.

It is important to use in the cast a thermoduct of the correct size and shape. When this is done, it is relatively easy to insert the thermoduct while the cast is being poured in the impression material. The remaining steps in the procedure for making a denture are then quite straightforward. The thermoducts which were used, having dimensions which were averages of those measured from specimen casts, varied sufficiently in size and shape to be entirely adequate for the dentures which were made.

It is particularly important to choose a thermoduct of the correct dimensions for a lower denture. Unless the thermoduct fits well and can be inserted in the cast so that it comes close to the bearing surface, an unusually high cast results. It may then be too large to mount accurately on an articulator. Fortunately, the design of the lower thermoducts permits the lower spacing plate to be removed to facilitate articulator mounting. This plate can be replaced when the denture is to be processed.

Photographs were made of a number of the dentures which were processed to show the shapes which were successfully handled and the texture of the finished dentures. Figures 10, 11 & 12 are photographs of dentures made by thermally controlled methods, showing the general shape of the cases.

Fig. 13 illustrates the external appearance of pink methyl methacrylate denture base material when unsatisfactorily processed. The speckled surface is caused by the red pigment surrounding the original polymer (powder) particles and is emphasized in these pictures because the photographic film was especially sensitive to red.

FIGURE 10.

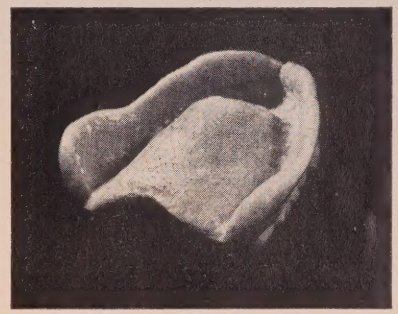

FIGURE 11.

FIGURE 12.

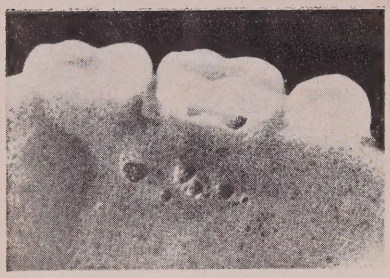

FIGURE 13.

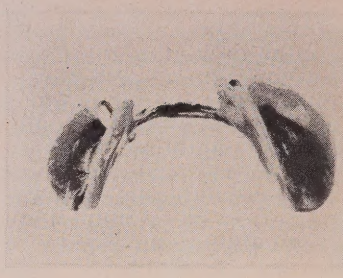

FIGURE 14.

The deep pits in the ridge of the denture and at the base of the first molar, are the severest form of porosity and were formed when this case was processed too rapidly.

Partial Dentures

In addition to the full dentures, two partial dentures were successfully made by the use of thermoducts.

In the pouring of stone casts for partial dentures where the impressions have been taken with a hydrocolloid impression material, such as Zelex, care should be taken to see that the important features, for example, the abutment teeth and the tissue surfaces, are not distorted by the weight of the thermoduct. This can be done by pouring a small amount of stone on to these surfaces and allowing it to set before pouring the rest of the cast and inserting the thermoduct. This procedure is sound practice even when a thermoduct is not used.

A photograph of a partial lower denture which was made by a controlled technique is shown in Fig. 14.

Evaluation of a Thermally-Controlled Method

The controlled method was compared with the technique used at the Dental College. This latter method did not make use of thermoducts and the heating cycle required one hour at 160° F., heating to 212° F. and one-half hour at 212° F. This cure is similar to one suggested by the manufacturers of the acrylic denture base material, Vernonite, and graphs[17] of this curing cycle show that peak temperatures are developed in the resin during the period at 160° F. and especially in thick sections which would frequently be encountered in lower dentures.

A thermally-controlled method requires a little less than one hour to complete the polymerization, thus effecting a saving of 45 minutes to one hour of processing time. It eliminates porosity by controlling the polymerization reaction, provided the prescribed heating cycle is adhered to and the flask is properly packed. It also adds a safety factor by preventing local overheating and ensuring that all parts of the denture base material polymerize at the same rate and presumably to the same degree, and, in cooling, it also prevents thermal inequalities. The thermoducts therefore tend to minimize internal strains. As far as external appearances are concerned no difference could be detected between practical dentures made by this method and those made by the Dental College method.

It was noted that the presence of thermoducts in the cast made deflasking very simple in that the relatively thin layer of artificial stone could be easily separated from the denture. This fact was also considered to be a distinct advantage in the use of thermoducts. In some cases where they are not used, it is very difficult to remove the cast and considerable care

is necessary to avoid damaging the denture.

Distortion Caused by Repairing

The problem of repairs requires further study because in the methods currently used some distortion usually occurs. Experience has shown that some internal strains are present in a denture no matter what method is used to process it. These strains are of no significance unless the denture is subjected to a high temperature for some time. Therefore it is best to make repairs at the lowest possible temperature. The usual method of repairing at 160° F. for several hours will cause a distortion of approximately ½ of 1 per cent. Repairing at 212° F., will distort the denture by more than 1 per cent.

Some preliminary results have been obtained which indicate that it may be possible to make a satisfactory repair at much lower temperatures than 160° F. and avoid distortion. As before, one requisite will be that the repair material must have adequate strength. In view of the close connection of this subject with that of making dentures it is hoped to complete a study of it very shortly and report the findings in a later paper.

Summary

This report summarizes recent investigations conducted at the Ontario Research Foundation on methyl methacrylate denture base materials.

Some physical properties of methyl methacrylate are described and some problems connected with the making of dentures are discussed.

A method for the rapid processing of dentures is presented. This method reduces the time necessary to cure a denture, controls the polymerization reaction by avoiding local overheating and eliminates porosity if the prescribed instructions are followed.

It was found that trial-packing cannot be eliminated conveniently, but with experience and by using the proper technique, the number of flask closures can be reduced to a minimum.

Shrinkage is discussed and it is shown that polymerization shrinkage is counter-balanced by expansion due to water adsorption so that the difference or net linear shrinkage is unimportant from a practical viewpoint.

It is disclosed that polishing by chemical methods should be avoided as solvents for the denture base material produce serious crazing.

Acknowledgement

The author is indebted to Mr. O. J. Schierholtz of the Ontario Research Foundation and Dr. R. L. Twible of the Faculty of Dentistry, University of Toronto for helpful advice and direction, and to Dean R. G. Ellis and Dr. R. J. Godfrey of the Faculty of Dentistry, University of Toronto, for providing facilities for the practical trials. The author also thanks Mr. F. T. Wood for technical assistance in making the trials and Mr. D. Riendeau and Mr. G. H. Lofts for the preparation of photographs.

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Appendix A

Dimensions of Thermoducts

The thermoducts which were used in making the practical cases de-

scribed in this paper were designed from the average dimensions of a number of upper and lower denture casts. Consideration was given to the fact that some mouths are wider and also more shallow than others. The thermoducts were first modelled in wax and then artificial stone was used to make master patterns. These were sent to a foundry where the thermoducts were cast in bronze.

Upper Thermoducts

Two basic types of upper thermoducts were required. In the first, the general shape of the arch or ridge can best be described as parabolic. This type of thermoduct is suited for narrow casts. The shape of the arch in the second type is elliptical and is adapted for wide casts. The other variable in upper thermoducts is the height of the ridge or the depth of the vault. In each of the two types, parabolic and elliptical, one thermoduct with a deep vault and one with a more shallow vault was used.

Lower Thermoducts

Lower thermoducts are necessarily different from upper thermoducts in design. In general, they are wider and more shallow. The bases of lower thermoducts are much thinner than those of uppers and the ridge rises at the posterior or distal ends of the arch to conform to the general shape of lower casts. These details can be seen in Figure 7. The most important variable in lower thermoducts is the width. At least three sizes are required to fit the majority of cases. The floor of the vault[1] does not have to be flat but may be arched to provide greater thermal conductivity for lingual flanges which are frequently rather thick in lower dentures.

The actual dimensions of the thermoducts which were used in processing the practical cases described in this paper are given in some detail in the following table.

These figures will provide four sizes of upper thermoducts and three sizes of lower thermoducts. They will be adequate for the majority of nor-

TABLE I

Dimensions of Thermoducts in Millimetres

	Upper	Lower
Width at back	58	64: 70: 76
Length of base	51	51
Overall height at back	25	22
" " " front	25	17[1]
Distance from back to crest of anterior ridge	45	45
Distance from back to base of anterior ridge = length of vault floor	29 and 32	35
Depth of vault = height of ridge	11 and 15	17[2]
Distance between ridges:		
(i) at back	45	51: 56: 61
(ii) at anterior of vault floor (elliptical)	37	33: 37: 41[3]
" " " " " (parabolic)	29	—

[1] In lower thermoducts the ridge starts to slope 15-20 mm. from the back.
[2] This figure applies to the height at the back of the thermoduct (See also footnote 1).
[3] The general shape of the arch in lower thermoducts is more or less elliptical.

1 The floor of the vault is the area enclosed by the arch. In Figure 7 it is shown by the horizontal broken line extending from the back of thermoduct to the base of the ridge.

mal cases. Abnormally large or small dentures may be encountered which would require special thermoducts but they are relatively rare. The necessary total number of thermoducts of all sizes would have to be determined by the number of dentures being made at any time.

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APPENDIX "S"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

To study the effects of altitude acceleration and deceleration on oral tissues.

Grant No.: DR 6

Grantee: R.C.D.C.

Summary of work:

Two hundred and fifty-seven flight cadets and other R.C.A.F. personnel were subjected to two decompression tests simulating 20,000 ft. and 30,000 ft. respectively.

A complete dental examination was given each subject between tests.

Personnel displaying dental symptoms under decompression were re-examined.

The incidence of dental complications during decompression tests is seen to be small, even in mouths requiring a great deal of attention.

From a survey of the results and observations of work in this field, it would seem that the prerequisites for aerodontalgia is a pathological disturbance or irritation of the pulp.

It would appear that the prevention of dental complications under lowered atmospheric pressure lies chiefly on the responsibility of good dentistry and the elimination of dental pathology. High altitude does not normally affect a healthy pulp. Except for cases of referred pain, the presence of some pre-existing pathological disturbance would seem to be the chief pre-requisite for toothache at altitude.

No relationship between toothache and other decompression reactions was found. The small number of personnel tested does not permit definite conclusions but a thorough and frequent examination accompanied by good dentistry would seem to eliminate most of the problems in this field.

October, 1948.

APPENDIX "B"

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	6. Dr. M. H. Garvin	31 March, 1950
	7. Dr. H. R. MacLean	31 March, 1950
	8. Dr. R. H. McDougall	31 March, 1949
	Rep. Royal Canadian Dental Corps	
*	9. Col. E. M. Wansbrough (ex officio)	--
	Rep. Division of Dental Health Dept. Nat. Health and Welfare	
	10. Dr. H. K. Brown	--
	Rep. Basic and Med. Sciences	
	11. Dr. C. H. Best	31 March, 1950
	12. Dr. J. B. Collip	31 March, 1949
	13. Dr. O. W. Ellis	31 March, 1951
	14. Dr. J.K.W. Ferguson	31 March, 1951
	15. Dr. J. J. Rae	31 March, 1950
	16. Dr. C. B. Stewart	31 March, 1951
*	17. Dr. D. L. Thomson	31 March, 1950
*	18. Mr. S. J. Cook, Secretary	--
	19. Master Copy (General Secretary)	--
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	Term to Expire
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2. President C. J. Mackenzie (ex officio)	--
Rep. Dental Profession	
3. Dr. H. K. Box	31 March, 1949
* 4. Dr. E. Charron	31 March, 1951
5. Dr. D. S. Coons	31 March, 1949
6. Dr. M. H. Garvin	31 March, 1950
7. Dr. U. R. Maclean	31 March, 1950
8. Dr. R. H. McDougall	31 March, 1949
Rep. Royal Canadian Dental Corps	
* 9. Col. E. M. Wansbrough (ex officio)	--
Rep. Division of Dental Health Dept. Nat. Health and Welfare	
10. Dr. H. K. Brown	--
Rep. Basic and Med. Sciences	
11. Dr. C. E. Best	31 March, 1950
12. Dr. J. B. Collip	31 March, 1949
13. Dr. O. W. Gillie	31 March, 1951
14. Dr. J.E.W. Ferguson	31 March, 1951
15. Dr. J. J. Rae	31 March, 1950
16. Dr. C. H. Stewart	31 March, 1951
* 17. Dr. D. L. Thomson	31 March, 1950
* 18. Mr. S. J. Cook, Secretary	--
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COPY NO. 1

NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS

OF THE

SIXTH MEETING

OF THE

EXECUTIVE

OF THE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

OTTAWA

3 MARCH, 1949

Proceedings of the Sixth Meeting

of the

EXECUTIVE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in Room 153, Chateau Laurier, 8 p.m., 3 March, 1949.

---

1. Attendance

Dr. R. G. Ellis, Chairman
Dr. E. Charron
Col. E. M. Wansbrough
Dr. D. L. Thomson

Mr. S. J. Cook, Secretary

By Invitation

Dr. R. H. McDougall

2. Chairman's Remarks

THE CHAIRMAN said that the principal business before the Executive was the consideration of applications for grants-in-aid, membership in the Committee, and decision as to such action as might be required regarding fellowships.

3. Applications for Grants-in-Aid

(a) RENEWALS

Applications for renewals of grants were recommended for approval for the year 1949-50 in the amounts indicated hereunder:

Grant No.	Grantee	Amount
		$
DR 1	Dr. J.J. Rae	1,000
DR 2	Dr. G.H.W. Lucas	325
DR 3	Dr. H. K. Box	100
DR 7	Dr. J. S. Bagnall	75
DR 9	Drs.O.J.Walker and H.R. MacLean	300
		1800

Fwd 1800

(continued)

Grant No.	Grantee	Amount
		$
DR 12 25	Dr. A.E.R. Westman (Application for $5000.)	4,000

There was considerable discussion on these applications in the course of which it was pointed out that if DR 25 is completed satisfactorily, DR 12 would appear to be unnecessary. It was noted also that the Committee has only available the same amount of funds for grants as it had during the past year and that there are several new applicants for assistance. After some discussion it was AGREED to ask the Ontario Research Foundation to proceed on the basis of $4,000 with a recommendation that the research be directed to the completion of one project according to their choice.

DR 13	Dr. M. Doreen Smith	1,475
DR 15	Dr. Norma Ford Walker	2,500

THE CHAIRMAN pointed out that Dr. Walker's application for $3,000 included $500 which was to be used for taxis to transport twins to the clinic. It had been decided last year that this item was an appropriate charge against the Committee's travel account and he suggested that this item be provided for in the same way again this year.

DR 18	Dr. H. K. Box	1,620
DR 19	Dr. J.K.W. Ferguson	350
DR 20	Dr. Jules Thébaud	750 (ENC.)

THE CHAIRMAN said that a report had been received during the day from Dr. Thébaud but there had been no opportunity as yet to review the report and to appraise the value of the work. He suggested therefore that the appropriation for renewal of the grant be encumbered.

DR 22	Dr. C. H. Best	2,400

There was considerable discussion on this application. It was finally agreed to recommend that the grant be reduced from $3,400 to $2,400 and that the grantee be asked to rearrange disposition of funds with a view to the completion of this phase of this project during the coming year.

DR 23	Dr. C. P. Leblond	2,200
DR 24	Dr. C.H.M. Williams	3,080

20,175

(continued)

Grant No.	Grantee	Amount
		$
DR 12	Dr. A.E.R. Westman	4,000
25	(Application for $5000.)	

There was considerable discussion on these applications in the course of which it was pointed out that if DR 25 is completed satisfactorily, DR 12 would not be necessary. It was noted also that one Committee has only available the same amount of funds for grants as it had during the past year and that there are several new applicants for assistance. After some discussion it was decided to ask the Ontario Research Foundation to proceed on the basis of $4,000 with a recommendation that the research be directed to the completion of one project according to their choice.

DR 13	Dr. M. Doreen Smith	1,475
DR 15	Dr. Norma Ford Walker	2,500

THE CHAIRMAN points out that Dr. Walker's application for $5,000 included $500 which was to be used for visits to transport cells to the clinic. It had been decided last year that this item was an appropriate charge against the Committee's travel account and he suggested that this item be provided for in this way again this year.

DR 18	Dr. H. K. Cox	1,000
DR 19	Dr. J.K.W. Ferguson	750
DR 20	Dr. Jules Thibaud	750 (50%)

THE CHAIRMAN said that a report had been received during the day from Dr. Thibaud but there had been no opportunity to review the report and to appraise the value of the work. He suggested therefore that the appropriation for renewal of the grant be encumbered.

DR 22	Dr. C. E. Dent	2,400

There was considerable discussion on this application. It was finally agreed to recommend that the grant be reduced from $3,400 to $2,400 and that the grantee be asked to rearrange disposition of funds with a view to the completion of this phase of this project during the coming year.

DR 23	Dr. C.C.F. Deihond	2,200
DR 24	Dr. [illegible]	2,000

Fwd 20175

(b) New Applications

	$
Dr. R. E. Moyers	1,300 ✓

The application was for $1,895. It was suggested that part of the equipment requested might be available through the National Research Council. The Committee recommended the grant be reduced to $1,300.

Dr. Abbiss and Dr. Nutlay	350 — 1000 + 650

The application was for $1,000 but this included $650 for a microtome which the Executive thought should be considered standard equipment in the laboratory.

Dr. M. Doreen Smith	1,500 ✓
Dr. Norma Ford Walker	2,000 — 1200 = 800
	#2625

The original application was for $2,400 all to be used for the salary of an assistant and on consideration it was AGREED to reduce the amount to $2,000.

(c) Applications Not Granted

DR 11 Dr. R. J. Godfrey

This application was discussed for about an hour. At first it was suggested that it should be referred back for review by a competent authority but it was pointed out that this had been done last year. It was also suggested that the grant should be made to Dr. Moses instead of to Dr. Godfrey in which event Dr. Moses would be ineligible to receive compensation for his work but would be able to employ junior helpers. Tribute was paid to Dr. Moses' enthusiasm but doubt was expressed that the recommendations of the Committee were being followed. It was felt that the work had never been carried out as originally planned, and now the point had been reached where the nature of the project was such that it was considered to be beyond the scope of both grantee and the assistant, and the longer the project went on the more difficult it would be to bring it to a satisfactory conclusion. It was finally decided to recommend that the grant be not renewed.

DR 16 Dr. C. H. Best

It was noted in the report on this subject that much of the time of the grantee is being devoted to project DR 22. After considerable discussion it was decided to request the grantee to concentrate on DR 22, which had

(b) New Applications

Dr. R. E. Moyers $1,500

The application was for $1,895. It was suggested that part of the equipment requested might be available through the National Research Council. The Committee recommended the grant be reduced to $1,500.

Dr. Abbias and Dr. Nutley $50

The application was for $1,000 but this included $950 for a microtome which the Executive thought should be considered standard equipment in the laboratory.

Dr. M. Dotsea Smith $1,500

Dr. Norma Ford Walker $2,000

The original application was for $2,900 all to be used for the salary of an assistant and on consideration it was AGREED to reduce the amount to $2,000.

(c) Applications Not Granted

DR II Dr. R. J. Godfrey

This application was discussed for about an hour. At first it was suggested that it should be referred back for review by a competent authority but it was pointed out that this had been done last year. It was also suggested that the grant should be made to Dr. Moses instead of to Dr. Godfrey in which event Dr. Moses would be ineligible to receive compensation for his work but would be able to employ junior helpers. Attitude was paid to Dr. Moses' enthusiasm but doubt was expressed that the recommendations of the Committee were being followed. It was felt that the work had never been carried out as originally planned, and now the point had been reached where the nature of the project was such that it was considered to be beyond the scope of both grantee and the assistant, and the longer the project went on the more difficult it would be to bring it to a satisfactory conclusion. It was finally decided to recommend that the grant be not renewed.

DR Ib Dr. C. H. Best

It was noted in the report on this subject that much of the time of the grantee is being devoted to project DR 22. After considerable discussion it was decided to request the grantee to concentrate on DR 22, which has

already received considerable support, without much evidence to date of definite results. It was decided not to renew the grant.

4. Membership of the Committee

THE CHAIRMAN reported that the terms of membership of five members in the Committee end 31 March, 1949; the members affected are - Dr. H. K. Box, Dr. J. B. Collip, Dr. D. S. Coons, Dr. A. W. Ham and Dr. R. H. McDougall. He pointed out that Dr. Coons had formerly been a representative of the Royal Canadian Dental Corps and that when he had retired from the Dental Corps he had been appointed as a private member for a period of three years. At the Executive meeting held 1 March, 1948, it had been agreed not to appoint a successor to Dr. Linghorne (who had also come on the Committee from the Royal Canadian Dental Corps) and not to make a nomination in succession to Dr. Coons when his term expired. This action was taken in order to restore the distribution of membership by professions to the basis agreed upon when the Committee was formed. Dr. Ham and Dr. McDougall had been named during the year in succession to Dr. Burton and Dr. Stibbs respectively to complete their terms.

It was AGREED to recommend the reappointment for a further term of three years Dr. Box, Dr. Collip, Dr. Ham and Dr. McDougall.

5. Fellowships

THE CHAIRMAN reported briefly on the subject of fellowships noting that the forms of application were being printed and that probably three fellowships would be awarded during the coming year. The notices called for the submission of applications prior to 1 March in each year but owing to the delay in securing approval for the scheme of dental research fellowships the notices would be over-stamped with a date of 1 June in the present year. Recommendations were made regarding the distribution of the notices and application forms to dental schools, associations, and dental journals as well as to the members of the Committee.

The Meeting adjourned at 10 P.M.

already received considerable support, without much evidence to date of definite results. It was decided not to renew the grant.

4. Membership of the Committee

THE CHAIRMAN reported that the terms of membership of five members in the Committee end 31 March, 1956; the members affected are - Dr. H. L. Box, Dr. T. B. Dolby, Dr. D. B. Coone, Dr. A. W. Ham and Dr. E. McDougall. He pointed out that Dr. Coone had formerly been a representative of the Royal Canadian Dental Corps and that when he had retired from the Dental Corps he had been appointed as a private member for a period of three years. At the Executive meeting held 1 March, 1956, it had been agreed not to appoint a successor to Dr. Clinborne (who had also come on the Committee from the Royal Canadian Dental Corps) and not to make a nomination in succession to Dr. Coone when his term expired. This action was taken in order to restore the distribution of membership by professions to the basis agreed upon when the Committee was formed. Dr. Ham and Dr. McDougall had been named during the year in succession to Dr. Burton and Dr. Stibbe respectively to complete their terms.

IT was AGREED to recommend the reappointment for a further term of three years Dr. Box, Dr. Dolby, Dr. Ham and Dr. McDougall.

5. Fellowships

THE CHAIRMAN reported briefly on the subject of fellowships noting that the forms of application were being printed and that probably three fellowships would be awarded during the coming year. The notices called for the submission of applications prior to 1 March in each year but owing to the delay in securing approval for the scheme of dental research fellowships the notices would be over-stamped with a date of 1 June in the present year. Recommendations were made regarding the distribution of the notices and application forms to dental schools, associations, and dental journals as well as to the members of the Committee.

The meeting adjourned at 10 P.M.

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* 1.	Dr. R. G. Ellis, Chairman	31 March, 1951
2.	President C. J. Mackenzie (ex officio)	--
	Rep. Dental Profession	
3.	Dr. H. K. Box	31 March, 1949
* 4.	Dr. E. Charron	31 March, 1951
5.	Dr. D. S. Coons	31 March, 1949
6.	Dr. M. H. Garvin	31 March, 1950
7.	Dr. H. R. MacLean	31 March, 1950
8.	Dr. R. H. McDougall	31 March, 1949
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* 9.	Col. E. M. Wansbrough (ex officio)	--
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10.	Dr. H. K. Brown (ex officio)	--
	Rep. Basic and Med. Sciences	
11.	Dr. C. H. Best	31 March, 1950
12.	Dr. J. B. Collip	31 March, 1949
13.	Dr. O. W. Ellis	31 March, 1951
14.	Dr. J.K.W. Ferguson	31 March, 1951
15.	Dr. A. W. Ham	31 March, 1949
16.	Dr. J. J. Rae	31 March, 1950
17.	Dr. C. B. Stewart	31 March, 1951
* 18.	Dr. D. L. Thomson	31 March, 1950
* 19.	Mr. S. J. Cook, Secretary	--
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	2. President C. A. Mackenzie (ex officio)	--
	Rep. Dental Profession	
	3. Dr. H. K. Box	31 March, 1949
*	4. Dr. R. Charron	31 March, 1951
	5. Dr. D. S. Goone	31 March, 1949
	6. Dr. M. H. Garvin	31 March, 1950
	7. Dr. H. R. Maclean	31 March, 1950
	8. Dr. R. E. McDougall	31 March, 1949
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*	9. Col. E. H. Wansbrough (ex officio)	--
	Rep. Division of Dental Health Dept. Nat. Health and Welfare	
	10. Dr. H. K. Brown (ex officio)	--
	Rep. Basic and Med. Sciences	
	11. Dr. C. H. Best	31 March, 1950
	12. Dr. I. R. Cottle	31 March, 1949
	13. Dr. O. W. Ellis	31 March, 1951
	14. Dr. J.K.W. Ferguson	31 March, 1951
	15. Dr. A. W. Hem	31 March, 1949
	16. Dr. J. J. Rae	31 March, 1950
	17. Dr. C. B. Stewart	31 March, 1951
*	18. Dr. D. L. Thomson	31 March, 1950
*	19. Mr. G. I. Cook, Secretary	--
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FACULTY OF DENTISTRY
OFFICE OF THE DEAN

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NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS

OF THE

NINTH MEETING

OF THE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

OTTAWA

3 - 4 MARCH, 1949

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Appendix "C"	Chemical mechanisms in dental caries, by J. J. Rae, DR 1.
Appendix "D"	Corrosion of dental materials by cleaning agents, by O.J. Walker and H.R. MacLean, DR 9.
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Appendices

Appendix "A" Investigation of materials for methyl methacrylate inlays, by A.E.R. Westman, DR 12.

Appendix "B" Investigation of repair techniques for methacrylate dentures, by A.E.R. Westman, DR 21.

Appendix "C" Chemical mechanisms in dental caries, by J. J. Rae, DR 1.

Appendix "D" Correction of dental materials by cleaning agents, by O.J. Walker and E.R. Wrolsen, DR 9.

Appendix "E" In vivo studies of certain fungus-like micro-organisms found in periodontal diseases, by G.H. Best, DR 10.

Appendix "F" Improvement of sub-gingival curettage and gum resection used in the treatment of the periodontal pocket, by J. Thébaud, DR 20.

Appendix "G" An investigation of the mechanism of repair of the supporting structure of the teeth, by C. H. Best, DR 22.

Appendix "H" Entry of phosphate and carbonate salts into teeth as shown with the help of radio-phosphorus and radio-carbon, by C. P. Leblond, DR 23.

Appendix "I" The effects of hard and soft diets on the supporting structures of the teeth, by C.H.M. Williams, DR 24.

Appendix "J" Investigation and critical report on dental caries research, by J. S. Bagnall, DR 7.

(Supplementing this summary in Appendix "J" is a list of the Division headings according to which the caries research review has been arranged).

Appendix "K" A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario, by M. Doreen Smith, DR 13.

Appendix "L" Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries, by M. Doreen Smith, DR 14.

Appendix "M" An anatomical, histological and physiological study of the temporo-mandibular joint, by R. J. Godfrey, DR 11.

Appendix "N" A study of alveolar oxygen tension and blood oxygen content during nitrous oxide anaesthesia, by R.J.S. Tickle and G.H.W. Lucas, DR 2.

Appendix "O" A comparison of ten local anaesthetics, by J.F. Aikenhead and J.K.W. Ferguson, DR 19.

Appendix "P" A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of the dental arches, by Norma Ford Walker, DR 15.

Appendix "Q" Experimental artificial production of dental caries in vitro, by H. K. Box, DR 18.

Appendix "R" To study the effects of decreased barometric pressure on the oral tissues, by E. M. Wansbrough, DR 6.

Appendix "S" Report of the Subcommittee on Publications.

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Appendix "H" Entry of phosphate and carbonate salts into teeth as shown with the help of radio-phosphorus and radio-carbon, by G. P. Lehland, DR 23.

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Appendix "S" Report of the Subcommittee on Publications.

Initial Distribution

NATIONAL RESEARCH COUNCIL

Proceedings

of the

NINTH MEETING

of the

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in Council Chamber, National Research Building, 9:30 a.m., 3-4 March, 1949.

---

1. Attendance

Dr. R. G. Ellis, Chairman
Dr. H. K. Box
Dr. E. Charron
Dr. D. S. Coons
Dr. O. W. Ellis
Dr. J.K.W. Ferguson
Dr. M. H. Garvin
Dr. A. W. Ham
Dr. H. R. MacLean
Dr. R. H. McDougall
Dr. J. J. Rae
Dr. D. L. Thomson
Col. E. M. Wansbrough

Mr. S. J. Cook, Secretary

By Invitation

Dr. R. A. Hugill
Dr. M. Doreen Smith
Dr. O. J. Walker

Apologies for their absence were received from Dr. C.H. Best, Dr. J.B. Collip, and Dr. C.B. Stewart.

2. Chairman's Remarks

THE CHAIRMAN welcomed Dr. Ham who was attending his first meeting of the Committee as a member. He also welcomed Dr. R. A. Hugill, Dr. M. Doreen Smith and Dr. O.J. Walker who had been invited to come to the meeting to present the results of researches on which they were engaged. He noted that the Committee is now entering upon its fifth year and he expressed his gratification at the satisfactory progress

NATIONAL RESEARCH COUNCIL

Proceedings

of the

NINTH MEETING

of the

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in Council Chamber, National Research Building,
9:30 a.m., 3-4 March, 1949.

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1. Attendance

Dr. R. G. Ellis, Chairman
Dr. H. K. Box
Dr. E. Cherron
Dr. D. S. Cooms
Dr. G. W. Ellis
Dr. J.K.W. Ferguson
Dr. M. R. Gervin
Dr. A. W. Ham
Dr. R. R. Meelsen
Dr. H. L. McDougall
Dr. J. J. Rae
Dr. D. L. Thomson
Col. E. M. Wansbrough

Mr. E. J. Cook, Secretary

By Invitation

Dr. R. A. Dugill
Dr. M. Doreen Smith
Dr. O. J. Walker

Apologies for their absence were received from Dr. C.H. Best, Dr. J.B. Collip, and Dr. G.E. Stewart.

2. Chairman's Remarks

THE CHAIRMAN welcomed Dr. Ham who was attending his first meeting of the Committee as a member. He also welcomed Dr. R. A. Dugill, Dr. M. Doreen Smith and Dr. O.J. Walker who had been invited to come to the meeting to present the results of researches on which they were engaged. He noted that the Committee is now entering upon its fifth year and he expressed his gratification at the satisfactory progress

which had been made under the Committee's auspices in the promotion of research projects of interest to dentistry. He said that he had arranged for a two day meeting in order that there might be ample time to review the reports from grantees and to consider the Committee's programme of work. A meeting of the Executive would be held at 8 o'clock in the evening at the Chateau Laurier to review applications in preparation for the second day meeting of the Committee.

3. Minutes of the 8th Meeting

It was MOVED by Dr. Charron and SECONDED by Dr. MacLean:

That the Minutes of the Eighth Meeting of the Committee, having been circulated, be taken as read and approved. CARRIED.

4. Publication of Papers (Min. 30, 8th Mtg.)

DR. FERGUSON said that he had received a letter from the Secretary noting the form which had been approved by the Executive as the wording to be used on reprints in acknowledgement of the financial assistance received by the grantee from the Associate Committee on Dental Research for the conduct of the reported investigation. He also noted that Council regulations on the publication of papers no longer require the grantee to secure permission from the Council and he presumed the same regulations apply in respect of Committees. He thought some changes should be made in the Committee's rulings regarding reprints and, after some discussion,

It was MOVED by Dr. Ferguson and SECONDED by Dr. Rae:

That a small Subcommittee be appointed by the Chairman to consider the matter of reprints and how they should be described. CARRIED.

THE CHAIRMAN appointed Dr. Ferguson, Dr. Garvin, Dr. Ham and Mr. Cook as members of the Subcommittee and asked them to report during the meeting.

5. Air Travel (Min. 5(ii). 8th Mtg.)

THE CHAIRMAN explained that permission to travel by air had been granted certain members of the Committee during the fiscal year 1948-49 and said that it would be necessary to make similar provision for air travel during 1949-50.

It was MOVED by Dr. O.W. Ellis and SECONDED by Dr. Charron:

That the Committee recommends that permission to travel by air to meetings of the Committee during 1949-50 be granted to Dr.M.H.Garvin, Dr. H.R. MacLean, Dr. R. H. McDougall, and Dr. C. B. Stewart. CARRIED.

THE CHAIRMAN pointed out that Dr. O.J. Walker who had been invited to attend this meeting had also travelled by air and he asked the Committee to authorize this travel.

It was MOVED by Col. Wansbrough and SECONDED by Dr. Charron:

That permission to travel by air to attend the Ninth Meeting of the Associate Committee on Dental Research be granted to Dr. O.J. Walker. CARRIED.

Reports of Grantees

6. DR 1 - Dr. J. J. Rae

"An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides"

DR. RAE presented a summary and an interim report on work done under his grant. These two documents appear in APPENDIX "C"

DR. COONS said there had been considerable publicity recently regarding the use of ammonia in toothpastes and he inquired whether any action by the Committee in this matter was contemplated.

THE CHAIRMAN said that he thought this subject was a matter which should be dealt with by the profession although the Committee would be pleased to offer advice if its assistance were invited.

DR. BOX said that there was considerable confusion both throughout the profession and in the minds of the public because of a lack of authentic information on dental caries. Some thought it was caused by acid which might be counteracted by alkaline materials such as ammonia but there were other types of caries which would not be affected by ammonia.

THE CHAIRMAN said that in regard to the first three points in Dr. Rae's programme there appeared to be some question as to the relationship between the presence of lactobacillus acidophilus and caries. Perhaps it was there as an effect rather than as a cause.

7. DR 2 - Dr. G.H.W. Lucas

"A study of alveolar oxygen tension and blood oxygen content during nitrous oxide anaesthesia"

DR. FERGUSON presented the report on this project which had been prepared by Dr. R.J.S. Tickle and Dr. G.H.W. Lucas. This report appears in APPENDIX "N"

DR. FERGUSON said that during the first few minutes in the administration of dental anaesthesia the question was how much oxygen is being lost from the body and that, having eliminated those patients who are unable to sustain oxygen loss, the question then became one of how long any healthy person could continue to withstand this treatment. It was accepted practice that more oxygen should be given in the later stages than initially and it was, of course, important to know whether the gas machines were delivering the quantities indicated by the dial settings. He suggested, however, that the statistics in relation to the number of patients who were adversely affected as the result of errors in the dial readings of gas machines are fallacious.

DR. CHARRON observed that machines are used generally in surgery for the administration of anaesthetics and that if any one machine was inaccurate the results could be serious. He thought means should be sought for the improvement of these machines.

DR. FERGUSON said that, in the Toronto General Hospital oxygenation was now being used following chest surgery and that in eighteen recent operations there had been no deaths whereas previous to the adoption of this practice some cases had been lost.

THE CHAIRMAN said that the attention of the Food and Drugs Laboratory had been drawn to the fact that some gas machines at present in use do not deliver gas in the amounts indicated by their dial settings and that any action in this matter would now rest with the Dominion authorities concerned in this field.

8. DR 3 - Dr. H. K. Box

" A study of micro-organisms found in periodontal pockets and dental caries as revealed by the electron microscope"

DR. BOX reported briefly on the progress of this investigation as follows:

" Twenty photographs of organisms present in material obtained from four gingival clefts were made with the electron microscope. These clefts are fissures

" in the gingival tissues which always involve the gingival margin. They split the outer gingival surface for varying distances and extend inwards to join a pocket.

Very little attention has been paid to gingival clefts by the dental pathologist and, in consequence, information has been lacking concerning their essential nature. A study of our material containing clefts has shown that these lesions are of great importance. One significant finding is that tracts can emanate from clefts and can penetrate the deeper tissues to a considerable depth. Also, organisms are found throughout tracts, including fine secondary ones which proceed from the main tract.

Tracts show practically no associated inflammatory reaction as evidenced by cellular infiltration. In this regard they differ from periodontal pockets which invariably show a fairly marked inflammatory infiltration in the soft tissue wall. The formation of clefts appears to be related to a fundamental destructive process of periodontal disease. Some examples suggest the action of an enzyme like hyaluronidase. As many bacteria produce hyaluronidases, a study of the organisms of the cleft therefore seems most important. It is interesting to note that in the material of the first two gingival clefts no spirochetes were found. They were present in the other two clefts. Other elements included bacillary forms with small round granules of varying sizes and larger inclusion bodies; very fine threads with expanded heads; course twisted threads; and clumps of material resembling mycelium. "

9. DR 4 - Dr. H. K. Box

"Periodontal Packs" - completed. Paper in the hands of J. Can. Dent. Assoc.

10. DR 5 - Dr. A. E. R. Westman

"Denture base materials" - completed. Paper published.

11. DR 6 - Col. E. M. Wansbrough

"To study the effects of altitude acceleration and deceleration on oral tissues"

COL. WANSBROUGH presented an interim report on this subject which appears in APPENDIX "R"

12. DR 7 - Dr. J. S. Bagnall

"Investigation and critical report on dental caries research"

THE CHAIRMAN read a summary of Dr. Bagnall's report which appears in APPENDIX "J"

Supplementing this summary in Appendix "J" is a list of the Division headings according to which the caries research review has been arranged.

THE CHAIRMAN said that he had heard from Dr. Bagnall and that he anticipated a final report on this project would be available at the October meeting in which event Dr. Bagnall would be invited to attend and present his complete report.

13. DR 8 - Dr. A.D.A. Mason

"D.M.F. caries incidence in Brantford children" - completed.

14. DR 9 - Drs. O.J. Walker and H. R. MacLean

"An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry"

DR. WALKER read a summary of the work and presented a full report both of which appear in APPENDIX "D"

DR. GARVIN inquired whether the dilutions used in the experiments listed in table 4 page "D4" were about as recommended by the manufacturers. Ans. Yes.

A short discussion ensued as to the advisability of quoting trade names in reports based on research work sponsored by the Committee.

DR. GARVIN suggested that the Committee knew in advance that some of the agents to be investigated were likely to be detrimental to denture materials; in his opinion results of experimental work carried out under the grant should be published.

DR. CHARRON said that it should be a matter of policy to show results of research work carried out under the Committee's direction to the appropriate authorities in order that corrective action might be taken when this was required. In his opinion also all papers based on work supported by the Committee should be examined by competent referees, before being published.

DR. O.W. ELLIS observed that corrosion is expressed in terms of loss of weight. He said that surface conditions of metals are an important factor in determining the extent of the corrosion which takes place on them. In the report the descriptions of the surface conditions of the metal were not precisely stated. Moreover most of the samples appeared to have been submitted to cold working and this alone has a considerable effect on rate of corrosion of the metal. For scientific accuracy all metals used in a test should be brought in to the same mechanical condition prior to being used in experimental work.

Luncheon adjournment 1-2 p.m.

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15. DR 10 - Dr. G. M. Macdonald

"Facial prostheses of vinyl resins" - completed.

16. DR 11 - Dr. R. J. Godfrey

"An anatomical, histological and physiological study of the ~~role of the condyle in mastication~~" temporomandibular joint.

THE CHAIRMAN presented a summary of the work done under Dr. Godfrey's direction. He also tabled a full report with illustrations. Both documents appear in APPENDIX "M"

DR. HAM reviewed the complete report and in doing so paid tribute to the enthusiasm of Dr. Moses in connection with this investigation. He said that the histo-pathological problems referred to in the report merit careful attention

and study but he took minor exception to some statements made in the report. He also doubted that it should be published. He thought the grantee might be directed back to the problem on articulation and asked to use different animals.

THE CHAIRMAN read an outline of the purpose of the investigation as described on the original application noting that it was the intention in the first instance to direct the study to the problem presented by the animal who has lost all teeth on one side only of his jaw.

DR. HAM said that it might be possible to take out some molars in an animal that has no big incisors and study the results.

DR. CHARRON said that in the light of the advice which had come to the Committee regarding this project he thought the work should now be discontinued.

THE CHAIRMAN said that an application for a further grant under this project had been received and he suggested that further discussion might be deferred until such time as the new applications were being reviewed. AGREED.

17. DR 12- Dr. A.E.R. Westman

"Investigation of cements for methyl methacrylate inlays"

DR. O.W. ELLIS presented the summary and report numbers 4802 and 4901 on this subject. He said that the minor changes in plan of procedure noted in the report had been agreed upon by the informal group which meets once a month in Toronto to discuss this particular project and plan the study. The summary and the two monthly reports 4802, and 4901 appear in APPENDIX "A"

18. DR 13- Dr. M. Doreen Smith

"A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario".

DR. M. DOREEN SMITH presented her own report. Both the summary and the full report appear in APPENDIX "K"

DR. WALKER suggested that it might be helpful to consult with The Electric Reduction Company of Canada Limited, Buckingham, Quebec, and also with the Consolidated Mining and Smelting Company of Canada Limited, Trail, B.C., as both of these firms are interested in the precipitation of fluorides with phosphates and have made a considerable study of the problem.

19. DR 14 - Dr. M. Doreen Smith

"Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries"

DR. SMITH read both the summary and the full report of her work on this project. Both documents appear in APPENDIX "L"

DR. RAE suggested that the water-soluble fluorides as distinct from calcium fluoride should be determined especially in foods as this information would be very helpful.

DR. WALKER mentioned that the first report on the smog disaster at Donora, Pa., had suggested fluorine as the cause of the smog but the final report of the investigation has not yet been published.

THE CHAIRMAN said that Dr. Smith's report under DR 14 raised some doubt as to the advisability of adding fluorides to certain communal water supplies.

20. DR 15 - Dr. Norma Ford Walker

"A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of the dental arches"

THE CHAIRMAN presented a summary of the work done under this project. The summary appears in full in APPENDIX "P"

21. DR 16 - Dr. C. H. Best

"In vivo studies of certain fungus-like micro-organisms found in periodontal disease"

THE CHAIRMAN presented a summary and a two-page report on this project which appear in full in APPENDIX "E"

22. DR 17 - Dr. R. F. Shaner

"An investigation of the effects of materials used in operative dentistry on the vital pulps of teeth"

DR. MACLEAN repeated the explanation which he had made at the previous meeting (Min. 23, 8th Mtg.), namely that Dr. Shaner had moved away from Edmonton and had been unable to continue the investigation in spite of the fact that he was very much interested in it.

Dr. MacLean hoped that he would be able to find a man who could carry the work forward under Dr. Shaner's

general direction. If this could be done the work would be proceeded with but no grant would be required at least at present.

23. DR 18 - Dr. H. K. Box

"Experimental artificial production of dental caries in vitro"

DR. R.A. HUGILL presented a summary and the complete report on this project which appear in APPENDIX "Q"

There was an animated discussion on these reports and Dr. Hugill was kept busy answering questions and making notes of various suggestions put forward by the members.

DR. RAE inquired how the 40 per cent pepsin was made and was told that 40 grams of crystals described as "Hartz pepsin enzyme crystals" were dissolved in 100 cc. water.

DR. THOMSON asked also about the 10 per cent ptyalin. It also was a "Hartz powder".

DR. RAE noted that 0.5 per cent hydrochloric acid was reported to give a pH of 4.5 while a 0.5 per cent lactic acid solution was also recorded as having a pH of 4.5. Similar questions were also directed by other speakers to Dr. Hugill.

DR. GARVIN drew attention to section 3 page "Q-15" and said that Dr. Gottlieb had reported that dental caries could be reduced by 90 per cent. He suggested that experiments be carried out to determine for the information of the profession whether this statement is true or not.

DR. HUGILL said he thought caries was the result of combined decalcification and proteolytic action.

24. DR 19 - Dr. E. A. Sellers

"Tissue toxicity and potency of local anaesthetics for topical application and nerve block in dentistry"

DR. J.K.W. FERGUSON presented a summary and report which appear in APPENDIX "O"

There was a lengthy discussion on these reports.

The first session concluded at 5 P.M.

SECOND SESSION - 9:30 a.m., 4 March, 1949

25. Attendance

Dr. R. G. Ellis, Chairman
Dr. H. K. Brown
Dr. E. Charron
Dr. D. S. Coons
Dr. O. W. Ellis
Dr. J.K.W. Ferguson
Dr. M. H. Garvin
Dr. A. W. Ham
Dr. H. R. MacLean
Dr. R. H. McDougall
Dr. J. J. Rae

Mr. S. J. Cook, Secretary

By Invitation

Dr. M. Doreen Smith
Dr. Jules Thébaud
Dr. O. J. Walker

An apology was received from Dr. H. K. Box who telephoned to say that he would be unable to attend this Session.

Reports of Grantees continued

26. DR 20 - Dr. J. Thébaud

"Improvement of sub-gingival curettage and gum resection used in the treatment of the periodontal pocket"

DR. THEBAUD presented a summary of his work and tabled a full report which has now been duplicated. Both documents appear in APPENDIX "F"

He also showed samples of sixteen different types of instruments that are illustrated and described in his report. In a letter sent with the report to the Secretary Dr. Thébaud referred to item sixteen of the regulations governing the award of grants for research in which it is provided that the Council shall be deemed to have an interest in any patents, rights covered by patent applications or patents taken out by the grantee on inventions or discoveries arising out of work done under a grant-in-aid. Dr. Thébaud said that he hoped his instruments could be registered and made available to periodontal surgeons.

SECOND SESSION - 9:30 a.m., 4 March, 1949

25. Attendance

Dr. R. G. Mills, Chairman
Dr. H. K. Brown
Dr. E. Charron
Dr. D. S. Coons
Dr. O. W. Mills
Dr. J.K.W. Fergusson
Dr. M. H. Gervin
Dr. A. W. Hall
Dr. H. R. Medlean
Dr. R. H. McDougall
Dr. J. J. Rae

Mr. S. J. Cook, Secretary

By Invitation

Dr. M. Doreen Smith
Dr. Jules Thibaud
Dr. O. I. Walker

An apology was received from Dr. H. K. Box who telephoned to say that he would be unable to attend this Session.

Reports of Trustees continued

26. DR CO - Dr. J. Thibaud

"Improvement of sub-gingival curettage and gum resection used in the treatment of the periodontal pocket"

DR. THIBAUD presented a summary of his work and tabled a full report which has now been duplicated. Both documents appear in

He also showed samples of sixteen different type of instruments that are illustrated and described in his report. In a letter sent with the report to the Secretary Dr. Thibaud referred to item sixteen of the regulations governing the award of grants for research in which it is provided that the Council shall be deemed to have an interest in any patents, rights covered by patent applications or patents taken out by the grantee on inventions or discoveries arising out of work done under a grant-in-aid. Dr. Thibaud said that he hoped his instruments could be registered and made available to periodontal surgeons.

27. DR 21 - Dr. A. E. R. Westman

"Investigation of repair techniques for methacrylate dentures"

DR. O.W. ELLIS presented a summary report and interim report Nos. 4808, 4901 (DR 21) and 4902, the last number being the final report on project DR 21. These four documents appear in APPENDIX "B"

He said that these reports concluded the work on denture materials at the Ontario Research Foundation.

28. DR 22 - Dr. C. H. Best

"An investigation of the mechanism of repair of the supporting structure of the teeth"

THE CHAIRMAN presented the summary and interim report on this work which appear in APPENDIX "G"

After some discussion hope was expressed that definite evidence of progress might be available on this project during the coming fiscal year.

29. DR 23 - Dr. C. P. Leblond

"Entry of phosphate and carbonate salts into teeth as shown with the help of radio-phosphorus and radio-carbon"

DR. HAM presented the summary report on this project which appears in APPENDIX "H"

He said that Dr. Leblond is a distinguished investigator in the use of radioactive materials in bone research who is frequently consulted by other research workers regarding methods and procedures. He was doing excellent work.

THE CHAIRMAN said that he would arrange to invite Dr. Leblond to attend the next meeting of the Committee to present his report in person.

30. DR 24 - Dr. C.H.M. Williams

"The effects of hard and soft diets on the supporting structures of the teeth"

THE CHAIRMAN presented a summary and report of work by Dr. Williams and Dr. Watt which appear in APPENDIX "I"

This concluded the presentation of reports by grantees.

31. Applications for Grants-in-Aid

(a) RENEWALS

The following applications for renewals of grants were approved in the amounts indicated for the year 1949-50:-

Grant No.	Grantee	Amount $
DR 1	Dr. J.J. Rae	1000
DR 2	Dr. G.H.W. Lucas	325
DR 3	Dr. H. K. Box	100
DR 7	Dr. J. S. Bagnall	75
DR 9	Drs.O.J.Walker and H.R.MacLean	300
DR 12) 25)	Dr. A.E.R. Westman (application for $5000) The Chairman reported that the Executive had suggested reduction of the application to $4000 with a suggestion that the Ontario Research Foundation be asked to allocate this amount between the two grants as they see fit. The reduction had to be made because of the limited funds available and the large number of applications received by the Committee.	4000
DR 13	Dr. M. Doreen Smith	1475
DR 15	Dr. Norma Ford Walker An additional $500 is to be made available out of the travel vote.	2500
DR 18	Dr. H. K. Box	1620
DR 19	Dr. J.K.W. Ferguson	350
DR 20	Dr. Jules Thébaud (Dr. Box is to report to the Executive regarding Dr. Thébaud's report. Executive will decide then whether grant is to be made.)	750 (ENC.)
DR 22	Dr. C.H. Best Application was for $3400 but Executive recommended that grantee be asked to rearrange disposition of funds on basis of $2400.	2400

11. Applications for Grants-in-Aid

(a) RENEWALS

The following applications for renewals of grants were approved in the amounts indicated for the year 1949-50:-

Grant No.	Grantee	Amount
		$
DR 1	Dr. J.J. Rae	1000
DR 2	Dr. D.H.W. Lucas	325
DR 3	Dr. H. K. Box	100
DR 7	Dr. J. S. Segrail	75
DR 9	Drs.O.J.Walker and H.R.McOlean	500
DR 12) 25)	Dr. A.E.R. Westman (application for $5000)	4000
DR 13	Dr. M. Doreen Smith	1475
DR 15	Dr. Norma Ford Walker	2500
DR 16	Dr. H. K. Box	1650
DR 19	Dr. J.K.W. Ferguson	350
DR 20	Dr. Jules Thebaud	750 (Exc.)
DR 22	Dr. C.H. Best	2400

		$
DR 23	Dr. C. P. Leblond	2200
DR 24	Dr. C.H.M. Williams A final report is expected at the end of this fiscal year.	3080

(b) NEW APPLICATIONS

DR 25 Dr. A. E. R. Westman (See DR 12)

DR 26 Dr. R. E. Moyers
A study of the normal and abnormal physiologic forces of the oral cavity. 1300

(Application was for $1895 but Executive recommended provision be made only for two items of equipment costing $1300).

DR 27 Dr. J.W. Abbiss and Dr. A.G. Nutlay
A histological study of tooth germ development, both intra and extra alveolar, with a survey of pathological changes in the developing tooth. 1000 (ENC.)

(Further investigation has to be made regarding availability of equipment in grantee's laboratory and subject is to be revised and made more specific. Executive authorized to approve grant if these conditions are met satisfactorily.)

DR 28 Dr. O.J. Walker and Dr. H.R. MacLean
Development of a method for determining fluorine by means of a photoelectric colorimeter.

(Executive recommended against making this grant but on discussion in Committee it was APPROVED.) 1000

DR 29 Dr. M. Doreen Smith
Biological absorption of fluorine 1500

DR 30 Dr. Norma Ford Walker
The study of the closure of space following premature loss of deciduous teeth.

(Executive had recommended reducing application from $2400 to $2000 but Committee decided to grant $1200 for six months work. Applicant may make a further application later.) 1200

DR 23 Dr. C. P. Lebland $300

DR 24 Dr. O.H.M. Williams $650
A final report is expected
at the end of this fiscal year.

(b) NEW APPLICATIONS

DR 25 Dr. A. E. R. Westman (See DR 12)

DR 26 Dr. R. K. Moyers $1300
A study of the normal and abnormal
physiologic forces of the oral
cavity.

(Application was for $1595 but
Executive recommended provision be
made only for two items of equip-
ment costing $1300).

DR 27 Dr. J.W. Ashies and Dr. A.O. Nutley $1000 (ENG.)
A histological study of tooth germ
development. Both intra and extra
alveolar, with a survey of patholo-
gical changes in the developing
tooth.

(Further investigation has to be
made regarding availability of
equipment in grantee's laboratory
and subject is to be revised and
made more specific. Executive
authorized to approve grant if
these conditions are met
satisfactorily.)

DR 28 Dr. O.J. Walker and Dr. R.R. Madigan $1500
Development of a method for determin-
ing fluorine by means of a photo-
electric colorimeter.

(Executive recommended against making
this grant but on discussion in Com-
mittee it was APPROVED.)

DR 29 Dr. M. Dorsey Smith $1500
Biological absorption of fluorine

DR 30 Dr. Morse Ford Walker $2000
The study of the closure of space
following premature loss of
deciduous teeth.

(Executive had recommended reducing
application from $2400 to $2000 but
Committee decided to grant $1500 for
six months work. Applicant may make a

(c) APPLICATIONS NOT GRANTED

DR 11 Dr. R. J. Godfrey

THE CHAIRMAN said that Dr. Godfrey's application for a renewal of his grant in the amount of $2700 had been considered at great length by the Executive but had not been approved. Several suggestions had been considered. It had been pointed out that the project had been reviewed and certain recommendations as to procedure had been made but it was felt that the investigation was not being restricted to the original project. Everyone recognized that Dr. Moses was an enthusiastic worker but the view had been expressed that it was doubtful whether the grantee or the assistant had the training in the field of histology to interpret their findings accurately.

After lengthy consideration it was MOVED by Dr. Ferguson and SECONDED by Dr. O.W. Ellis:

That the Committee concur in the recommendation of the Executive that the renewal application under DR 11 be not approved. CARRIED.

DR 16 Dr. C. H. Best

THE CHAIRMAN said that the Executive had discussed this application in detail. The report indicated that much of the time of the grantee was devoted to project DR 22. After considerable discussion the Executive's recommendation that the grant be not approved was AGREED.

32. Amount of Grants

	$
Total amount voted (including $1750 encumbered)	26,175
Balance available for grants	1,325
Total appropriation for grants (1949-50)	27,500

33. Fellowships (Min. 29, 7th Mtg.)

THE CHAIRMAN reported that the programme of fellowships had been approved by the National Research Council and the necessary forms were now in the hands of the printer. The notices called for the submission of applications prior to 1 March in each year but owing to the delay in securing approval for the scheme of dental research fellowships the notices would be over-stamped with a date of 1 June in the present year. Fellowships will be of two classes (a) $1500 per annum, open to graduates in dentistry with high academic standing or who have spent at least one

(c) APPLICATIONS NOT GRANTED

DR 11 Dr. R. J. Godfrey

THE CHAIRMAN said that Dr. Godfrey's application for a renewal of his grant in the amount of $2,700 had been considered at great length by the Executive but had not been approved. Several suggestions had been considered. It had been pointed out that the project had been reviewed and certain recommendations as to procedure had been made but it was felt that the investigation was not being restricted to the original project. Everyone recognized that Dr. Moore was an enthusiastic worker but the view had been expressed that it was doubtful whether the grantee or the assistant had the training in the field of histology to interpret their findings accurately.

After lengthy consideration it was MOVED by Dr. Ferguson and SECONDED by Dr. O.W. Mills:

That the Committee concur in the recommendation of the Executive that the renewal application under DR 11 be not approved. CARRIED.

DR 16 Dr. O. H. Best

THE CHAIRMAN said that the Executive had discussed this application in detail. The report indicated that much of the time of the grantee was devoted to project DR 22. After considerable discussion the Executive's recommendation that the grant be not approved was ADOPTED.

32. Account of Grants

Total amount voted (including $1,750 announced)	$ 26,1?5
Balance available for grants	1,325
Total appropriation for grants (1949-50)	$?7,500

33. Fellowships (Min. 89, Pts Mtg.)

THE CHAIRMAN reported that the programme of fellowships had been approved by the National Research Council and the necessary forms were now in the hands of the printer. The notices called for the submission of applications prior to 1 March in each year but owing to the delay in securing approval for the scheme of dental research fellowships the notices would be over-stamped with a date of 1 June in the present year. Fellowships will be of two classes (a) $1500 per annum, open to graduates in dentistry with high academic standing or who have spent at least one

year in postgraduate training and (b) $1600 to $2500 per annum open to graduates in dentistry who have had experience in research work. The value of these latter fellowships will depend on the candidates' training and achievement in original research. For this year $5000 have been provided in the Committee's estimates for fellowships which would permit the granting of one senior and two junior fellowships this year if suitable applicants are found. He said that copies of the notices and a supply of application forms would be sent to deans of dental schools, the Canadian Dental Association, Dental Journals such as The Journal of the Canadian Dental Association, Oral Health, Ontario Dental Journal and Journal of the American Dental Association; the Royal Canadian Dental Corps; Registrars of Canadian universities and members of the Committee.

After some discussion it was MOVED by Dr. McDougall and SECONDED by Dr. O.W. Ellis:

That the Executive be empowered to deal with applications for fellowships received for 1949-50. CARRIED.

34. Membership of the Committee

THE CHAIRMAN reported that the terms of membership in the Committee of five members end on 31 March 1949; the members affected are: Dr. H. K. Box, Dr. J. B. Collip, Dr. D.S. Coons, Dr. A. W. Ham and Dr. R. H. McDougall. In the case of Dr. Box and Dr. Collip he noted that they had both been appointed on the original Committee in 1945 for a period of one year and in 1946 had been named for a second term of three years. At the first meeting of the Committee held 1 June 1945, it was provided that "A retiring member may be appointed for a second term following which he shall retire from the Committee for at least one year". This rule does not apply to the representatives of Royal Canadian Dental Corps, since they are members ex officio, they "remain members of the Committee for such period as each continues to represent the Dental Corps on the Committee".

Dr. Ham was appointed only this year to complete the term of Dr. E. F. Burton.

Dr. Coons had succeeded Brig. F.M. Lott in 1946 as a member of the Committee from the Royal Canadian Dental Corps and on his retirement from the Dental Corps had been named as a private member of the Committee for a period of three years.

At the Fourth Executive held 1 March, 1948, membership of the Committee was considered (Min.12) and the Executive recommended that both last year and

this year the membership in the Committee should be reduced by one in order to restore the distribution of membership from the dental profession to the basis agreed upon when the Committee was formed. There is now only one representative from the Royal Canadian Dental Corps, (The Director General). In accordance with the decision reached last year the Executive recommends that no appointment be made in succession to Dr. Coons.

Some discussion arose as to what constituted two terms. It was pointed out that some members had only served one year in their first term and three years in their second term.

THE CHAIRMAN said that the reason for the short term given some members when the Committee was formed was to establish a proper system of rotation and that legally such a one-year term might be considered as equivalent to one full term of office. He pointed out that there would be even more difficulty in deciding this question in respect of the members who had served one two-year term followed by a three-year term.

It was MOVED by Dr. Rae and SECONDED by Dr. MacLean:

> That the recommendations made in regard to renewal of memberships in the Committee be referred back to the Executive for further consideration and clarification of the rule regarding what constitutes a two-term membership in the Committee.
>
> CARRIED.

It was MOVED by Dr. Garvin and SECONDED by Dr. O.W. Ellis:

> That the appointment of Dr. A.W. Ham and Dr. R. H. McDougall for a further term of three years from 1 April 1949 be recommended, to the National Research Council. CARRIED.

35. Report of Subcommittee on Publications

DR. J.K.W. FERGUSON presented a report from the Subcommittee appointed to study the question of reprints and publications of the Associate Committee on Dentistry. The Subcommittee recommended that certain earlier minutes be rescinded and replaced by new items defining the Committee's policy regarding papers published on work supported financially by the Committee. The report was discussed at some length and as there appeared to be some difference of opinion in regard to the recommendations made,

It was MOVED by Dr. Ferguson and SECONDED by Dr. Garvin:

That the report of the Subcommittee on Publications be received and included with the proceedings for consideration by the members and decision as to the necessary action at the next meeting of the Committee. CARRIED.

The report of the Subcommittee appears in full in APPENDIX "S"

36. Remarks by Dr. Coons

DR. COONS said that since this was his last meeting with the Committee he would like to say how much he had enjoyed working with the members and how gratified he was with the progress that had been achieved since he first came to the Committee as a representative of the Royal Canadian Dental Corps. He had appreciated the honour of being named a member in his own right for a further term and he wished the Committee great and continued success in its efforts to stimulate and promote research in dentistry and allied fields.

THE CHAIRMAN thanked Dr. Coons for his kind remarks and said that the Committee had been greatly helped by the way in which Dr. Coons had interested the dental profession in the work of the Committee.

37. Date of Next Meeting

It was AGREED to hold the next meeting of the Committee some time in October 1949 at the call of the Chair.

The Meeting adjourned at 3 P.M.

APPENDIX "A"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Investigation of cements for methyl methacrylate inlays.

Grantee: Dr. A.E.R. Westman

Project: DR 12 Amount of Grant: $5000 (including DR 21)

SUMMARY OF WORK

Complete details of the work done on this project to date can be found in our regular progress reports which appear in one of the appendices.

Although this investigation was originally concerned with the development of a cement for methacrylate inlays, our attention has more recently been directed to the problem of direct intra-oral fillings of methyl methacrylate.

Progress has been made in this research where the factors involved are those dealing with the low-temperature rapid polymerization of methyl methacrylate. Tertiary amines, both aliphatic and aromatic, are effective accelerators but the tertiary aliphatic amines, e.g., trihexylamine, are less prone to cause discoloration of the resin. Recently, the sulfinic acids, such as p-toluene sulfinic acid, have been announced as low-temperature polymerization catalysts. It is proposed to investigate their use.

The development of a suitable acrylic filling material will not entirely circumvent the need for a cement for methacrylate inlays or jacket crowns. It is intended, therefore, to revive the work on cements in an attempt to develop a material more satisfactory than the currently used zinc phosphate cements.

APPENDIX "A"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Ref. No. 1942

Subject: Investigation of cements for methyl methacrylate inlays.

Grantee: Dr. A.E.R. Westman

Project: DR 12 Amount of Grant: $5000 (including DR 21)

SUMMARY OF WORK

Complete details of the work done on this project to date can be found in our regular progress reports which appear in one of the appendices.

Although this investigation was originally concerned with the development of a cement for methacrylate inlays, our attention has more recently been directed to the problem of direct intra-oral fillings of methyl methacrylate.

Progress has been made in this research where the factors involved are those dealing with the low-temperature rapid polymerization of methyl methacrylate. Tertiary amines, both aliphatic and aromatic, are effective accelerators but the tertiary aliphatic amines, e.g., triethylamine, are less prone to cause discoloration of the resin. Recently, the sulfinic acids, such as p-toluene sulfinic acid, have been announced as low-temperature polymerization catalysts. It is proposed to investigate their use.

The development of a suitable acrylic filling material will not entirely circumvent the need for a cement for methacrylate inlays or jacket crowns. It is intended, therefore, to revive the work on cements in an attempt to develop a material more satisfactory than the currently used zinc phosphate cements.

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4802 - DR 12

Scope of This Report

This report is concerned with matters pertaining to the making of direct acrylic inlays. Room-temperature catalysts or accelerators are discussed as well as an apparatus for curing inlays at temperatures slightly above mouth temperature.

Nuweld Accelerator

It has been pointed out previously that the liquid component of Nuweld denture repair material can be used with acrylic inlay powders containing benzoyl peroxide to produce inlays which set rapidly at body temperature or even at room temperature. However, some discoloration of the inlay occurs.

A short time was spent on an investigation of the accelerator used in Nuweld liquid. Small amounts of this material can be obtained by evaporating a quantity of the monomer. Taken up in capillary pipettes, the accelerator is a liquid having a yellow to amber color. Its boiling point at 740 mm. pressure as determined by a micro-method after one fractionation according to the method of Emich was found to be 203 - 205°C. An attempt was made to determine its molecular weight by a cryoscopic method using camphor and also naphthalene as a solvent. Satisfactory results were not obtained probably because decomposition occurred or the accelerator was incompletely soluble in the solvents. However, on the basis of the experimental work its molecular weight is probably between 110 and 180. Since the accelerator is thought to be a tertiary amine containing at least one aromatic group, even this comparatively wide range of molecular weights narrows the field of possible compounds.

Several amines have been obtained and tested for catalytic activity at room temperature on monomer-polymer mixtures of methyl methacrylate. Secondary aryl alkyl amines such as methylaniline, ethylaniline and butylaniline do not act as accelerators and cause intense blue discolorations of the methacrylates. This discoloration is caused by the reaction of the amines with benzoyl peroxide. The possibility that the accelerator in Nuweld is an amine of this type is fairly well eliminated.

Tertiary aryl alkyl amines such as dimethyl aniline (Mol. wt. = 121) and dibutyl aniline (Mol. wt. = 205) do have accelerating properties. The dimethyl- and dibutyl anilines produce rapid hardening of the methacrylate mixture at room temperature. An orange discoloration such as that observed in Nuweld repair material occurs. The odor of dimethyl aniline is somewhat offensive while the Nuweld accelerator has a not unpleasant aromatic odor.

The following tertiary amines were also tested for accelerating properties at room temperature: methyl diphenyl-amine, myristyl dimethylamine, tribenzylamine, dimethylbenzyl-amine and methylbenzylaniline.

Of these, only methylbenzylaniline was particularly reactive. It caused hardening of the monomer-polymer mixture in about 45 minutes at room temperature and the color of the mixture was only slightly off-shade. The others were extremely slow and only methyldiphenylamine caused discoloration.

Thus, the N-substituted anilines are the only amines, of those which we have tried, that cause rapid hardening of methacrylates at room temperature. Like aniline, these com-pounds are, in all probability, poisonous. On the other hand, it should be considered that in an average inlay, the total quantity of accelerator if used in 3% concentration, would not likely exceed 1 milligram.

The table below lists the amines which we have investigated in a brief qualitative manner.

Table I

Amine	Formula	Mol. Wt.	Reactivity	Remarks
Methylaniline	$C_6H_5-N(H)-CH_3$	107	None	Blue discoloration
Ethylaniline	$C_6H_5-N(H)-C_2H_5$	121	None	Blue discoloration
Butylaniline	$C_6H_5-N(H)-C_4H_9$	149	None	Blue discoloration
Dimethylaniline	$C_6H_5-N(CH_3)-CH_3$	121	Less than 20 min.	Orange discoloration Toxic
Dibutylaniline	$C_6H_5-N(C_4H_9)-C_4H_9$	205	Less than 25 min.	Orange discoloration Toxic
Methylbenzylaniline	$C_6H_5-N(CH_3)-CH_2-C_6H_5$	197	Less than 45 min.	Very slight discoloration Toxic
Dimethylbenzylamine	$CH_3-N(CH_3)-CH_2-C_6H_5$	135	Very slow if any	Color O.K. Fishy odor
Methydiphenylamine	$C_6H_5-N(CH_3)-C_6H_5$	183	Very slow if any	Orange discoloration
Myristyldimethylamine	$CH_3-N(CH_3)-(CH_2)_{13}-CH_3$	241	Very slow if any	Color O.K.
Tribenzylamine	$(C_6H_5CH_2)_3-N$	287	Very slow if any	Color O.K.

Some of the amines with slow reactivity at room temperature might possibly be more effective at slightly elevated temperatures such as those that could be used in curing direct inlays.

Sulfinic Acids

We have recently translated a German paper[x] on the use of sulfinic acids as catalysts for the rapid polymerization of vinyls (including methyl methacrylate) at room temperature. This paper is of recent origin, apparently having been received by the publishers on August 25th of this year. The authors are Gebruder de Trey, Zurich, Switzerland. The subject of the paper and the name of the authors suggest that it is the same de Trey company which manufactures dental materials.

The paper claims that sulfinic acids, such as p-toluene sulfinic acid, can be used as accelerators of the polymerization of methyl methacrylate monomer-polymer doughs at room temperature and that absolutely no discoloration occurs. The paper also states briefly that "tertiary amine oxides give products which discolor in light".

It is considered here that these compounds should receive some attention. At the present time, we are carrying out the preparation of the acid described in the paper, viz. p-toluene sulfinic acid.

Inlay Heater

It has been demonstrated that direct acrylic inlays can possibly be made using trihexylamine as a catalyst and with the application of moderate heat such as can be conveniently obtained from a 8-mm. motion picture projector.

We have inquired further into the possibility of developing an instrument to be used for this purpose. Instruments, such as slide or film projectors, were examined and considered to be too expensive, inefficient and generally unsuitable without extensive modification. Lamp housings of projectors, which contain all the essential components of a suitable heater, can not be obtained as they are only available as integral parts of the projectors. However, the parts can be obtained. The cost of a mirror, a lamp and its base and the condensing lenses mounted in an assembly would be about $15. A heater could be constructed here, in which case there would be additional charges for labor and other parts.

x Helvetica Chimica Acta XXXI, 1624 (1948)

November 29, 1948.

Douglas R. Christie,
Research Fellow

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4901 DR 12

Scope of This Report

Additional investigations are described on materials with possibilities as accelerators for the polymerization of direct acrylic inlays.

Tertiary Amines

It has been shown that tertiary amines, and in particular the N-disubstituted anilines, such as dimethyl-aniline, (DMA), when used in conjunction with benzoyl peroxide (BPO) are capable of promoting the rapid polymerization of methyl methacrylate monomer-polymer mixtures at room temperature. However, the polymerization is attended by a rather serious discoloration of the resin which precludes their use in direct acrylic inlays.

Several other peroxides and hydroperoxides were investigated to determine if they also would cause adverse color effects. Among those tested were: lauroyl peroxide, succinic acid peroxide, Uniperox 60, tertiary-butyl perbenzoate and p-chlorobenzoyl peroxide. None of these compounds added to a 2 per cent solution of DMA in methyl methacrylate monomer showed any outstanding accelerating effects and all of them caused some discoloration.

Peroxides in the Polymer Powders

An incidental experiment led to a study of the polymer powders. Uniperox 60 was added to a 2 per cent solution of DMA and mixed with ordinary denture base material polymer. It was surprising to find that this combination on warming set very rapidly. For example, at 100° F. a mixture containing 2% DMA and 1.5% Uniperox 60 in the monomeric component polymerized, with considerable evolution of heat, in 11½ minutes. When DMA and Uniperox 60 were both 1% in the monomer, the mixture hardened in 17 minutes.

Since the combination of DMA and Uniperox 60 was ineffective in polymerizing methyl methacrylate monomer at 100°F., it was immediately suspected that the polymer must contain something (probably BPO) which was the factor necessary to produce the rapid polymerization.

As a first step in proving this assumption, the Uniperox 60 was omitted and a 2% solution of DMA in the monomer was mixed with ordinary denture base polymer. The mixture was placed in a test tube and immersed in a water bath at 100°F. and the temperature of the resin recorded with a thermocouple. Polymerization was indicated by a rapid rise in temperature after a period of about 13 minutes. Obviously the Uniperox 60 was not a necessary constituent.

An attempt was made to remove the unknown in the polymer by washing it for a few minutes in ethyl alcohol, filtering and drying. The attempt was unsuccessful because a mixture made with the washed polymer and the DMA solution still polymerized in less than 15 minutes.

The polymer was then washed with glacial acetic until some dissolution had occurred. Potassium iodide was added to reduce any peroxide present and sodium thiosulphate was also added to consume any free iodine. The polymer was again filtered, washed with water, dried, ground and mixed with DMA solution. This time no reaction occurred in an hour but an orange discoloration developed which was later found to be caused by the washing method or, more precisely, because of the inability to remove the reaction products of the reduction.

Analysis of Polymer for BPO

An analysis for BPO was carried out in the following manner. About 5 grams of polymer was dissolved in about 40 ccs. of glacial acetic acid. The air above the solution in the flask was flushed out with carbon dioxide. One cc. of a 50% aqueous solution of potassium iodide was added and the solution allowed to stand under CO_2 for 10 minutes. During this time a yellow coloration due to free iodine develops. 50 ccs. of water and 10 ccs. of toluene were then added and the iodine determined with standard sodium thiosulphate using starch as an indicator.

Lucitone denture base material (pink) was found to contain 0.39% BPO. It was assumed that BPO was the peroxide under consideration because it is the peroxide most commonly used in the manufacture of methyl methacrylate. Nuweld polymer was also analyzed for peroxides and was found to contain 0.9% as BPO. This amount seems far in excess of the quantity actually required. Increasing the BPO content of a low-temperature setting monomer-polymer mixture tends to intensify the discoloration caused by the reaction between the BPO and the tertiary amine.

p-Toluenesulfinic Acid

The last report gave a preliminary description of this accelerator based on a translation of a German paper.

Sodium p-toluenesulfinate was prepared here in good yield and a quantity of the acid has been isolated. We have not had occasion to use it except for a few qualitative experiments, because a 20-gram sample in a dry state has been received from de Trey Frères, Switzerland, following a letter to them. As anticipated, de Trey Frères are manufacturers of dental products. The author of the above-mentioned paper informed the writer that he was not in a position to give any information about the subject other than that already presented.

Toluenesulfinic acid (TSA) causes monomeric methyl methacrylate to gel in about 2 hours at 100°F. This is much faster than BPO or DMA and BPO under the same conditions. In addition, no discoloration occurs.

However, for some reason a monomer-polymer mixture containing TSA does not polymerize rapidly at room temperature. One test required about 4 hours for the mixture to become hard. This time is decreased, of course, at higher temperatures so that between 130 and 140° F. about 15 minutes is required.

In view of the fact that ordinary methyl methacrylate dental powders contain some peroxides, it is conceivable that the TSA in a mixture is being oxidized to toluenesulfonic acid which would be ineffective in promoting polymerization. A study of the behavior of TSA in the absence of peroxides is now being carried out.

Nuweld Accelerator

Another brief investigation of the accelerator contained in Nuweld has been done. A derivative of the accelerator formed with methyl p-toluene-sulfonate has been prepared according to a method of Marvel et al.[x]

A white, crystalline solid was obtained. Its melting point, determined by the Kofler micro method, was 199.5-200°C. No derivative of a tertiary amine with this melting point is listed in Marvel's original paper. However, data are missing for several amines which have become more readily available since that time. A continuation of this work, as yet unpublished may have been carried out. Inquiries are being made.

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[x] J.A.C.S. 51, 3638, (1929)

Inlay Heater

The essential parts for an inlay heater have been obtained. The 300-watt projection lamp, which would be the source of heat, measures over 5 inches in length and was therefore considered to be somewhat large for the purpose in that it might make the apparatus unwieldy. The Canadian General Electric Company has just begun to manufacture for the first time in Canada a 125-watt projection lamp which is about 3 inches in length. This lamp should be ideal for our needs and we have been promised one within the next week.

January 6, 1949.

Douglas R. Christie
Research Fellow.

APPENDIX "B"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Investigation of repair techniques for methacrylate dentures.

Grantee: Dr. A.E.R. Westman

Project: DR 21 Amount of Grant: $5,000 (including DR 12)

SUMMARY OF WORK

Regular monthly reports on this project have been submitted to the Associate Committee. Investigations on this project have dealt with low-temperature repair techniques for methyl methacrylate dentures.

Details of a method for effecting repairs in dentures without distortion with the use of ultra-violet light were just being completed at the time of the last Associate Committee meeting. Since that time we have undertaken to repair actual dentures in order to test the suitability of the method. This work is still being continued and final results should be available in the near future. A brief survey of room-temperature-setting repair materials has also been made.

It is anticipated that this project will be completed within two months. A summary report will then be submitted and, with the approval of the Associate Committee, a paper will be prepared for publication.

27 January, 1949

APPENDIX "B"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Investigation of repair techniques for methacrylate dentures.

Grantee: Dr. R.F. Weston

Project: DR 21 Amount of Grant: $5,000 (including DR 12)

SUMMARY OF WORK

Regular monthly reports on this project have been submitted to the Associate Committee. Investigations on this project dealt with low-temperature repair techniques for methyl methacrylate dentures.

Details of a method for effecting repairs in dentures without distortion with the use of ultra-violet light were just being completed at the time of the last Associate Committee meeting. Since that time we have undertaken to repeat actual dentures in order to test the suitability of the method. This work is still being continued and final results should be available in the near future. A brief survey of room-temperature-setting repair materials has also been made.

It is anticipated that this project will be completed within two months. A summary report will then be submitted and, with the approval of the Associate Committee, a paper will be prepared for publication.

27 January, 1949

APPENDIX "B"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4808 - DR 21

Ultra-Violet Repair Method

No damaged dentures have been received from the Dental College of the University of Toronto since the last report, therefore it has been impossible to carry out further evaluations of the ultra-violet method for repairing dentures. We have been assured, however, that additional cases will be submitted to us. When we have successfully dealt with a number of actual repairs we will be able to prepare a final report on this project.

Nuweld Denture Repair Material

A few tests of this material have been carried out but we have not completed our evaluation of it. Knoop hardness values were determined after various time intervals on a sample prepared according to instructions and cured under pressure in a mold at room temperature. These values are presented below.

Time	K.H.N.
0.5 hrs.	8.1
1 "	10.5
2 "	10.7
24 "	10.9
4 days	12.4
20 "	13.9

It will be seen that considerable hardening takes place in the first 24 hours but the material is still softer after nearly three weeks than methacrylate denture base material which is cured at 135° F. for 16 hours (K.H.N. = 15.5) or by the ultra-violet method which requires 3 ½ hours (K.H.N. =18).

It should be observed, however, that, although maximum hardness is probably desirable, hardness in itself is no criterion of a suitable denture base material. We have not been able to carry out transverse strength tests on this material because we are awaiting the arrival of a new dial gauge for our transverse strength testing instrument. When this replacement is received, we shall investigate the strength of Nuweld repair material.

November 29, 1948.

Douglas R. Christie,
Research Fellow.

APPENDIX "B"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4803 - DR 21

Ultra-Violet Repair Method

No damaged dentures have been received from the Dental College of the University of Toronto since the last report, therefore it has been impossible to carry out further evaluations of the ultra-violet method for repairing dentures. We have been assured, however, that additional cases will be submitted to us. When we have successfully dealt with a number of actual repairs we will be able to prepare a final report on this project.

Nuweld Denture Repair Material

A few tests of this material have been carried out but we have not completed our evaluation of it. Knoop hardness values were determined after various time intervals on a sample prepared according to instructions and cured under pressure in a mold at room temperature. These values are presented below.

Time	K.H.N.
0.5 hrs.	8.1
1 "	10.5
2 "	10.7
24 "	10.9
8 days	12.4
20 "	13.9

It will be seen that considerable hardening takes place in the first 24 hours but the material is still softer after nearly three weeks than methacrylate denture base material which is cured at 155° F. for 16 hours (K.H.N. = 15.5) or by the ultra-violet method which requires 3 ½ hours (K.H.N. =15).

It should be observed, however, that although maximum hardness is probably desirable, hardness in itself is no criterion of a suitable denture base material. We have not been able to carry out transverse strength tests on this material because we are awaiting the arrival of a new dial gauge for our transverse strength testing instrument. When this replacement is received, we shall investigate the strength of Nuweld repair material.

November 20, 1944.

Douglas R. Ontario,
Research Fellow.

APPENDIX "B"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4901 DR 21

Scope

This report is concerned with transverse strength tests on Nuweld denture repair material.

Transverse Strength of Nuweld

Nuweld plain and mottled powders were studied. Flat plates measuring about 1/8" x 2" x 2-5/8" were made in plaster molds at room temperature. To one volume of Nuweld liquid were added 3 volumes of Nuweld powder as indicated in the manufacturer s instructions. When the mixtures reached a doughy consistency they were packed in plaster molds in dental flasks and allowed to cure under pressure for half an hour at room temperature. Two plates were made with plain powder and two with mottled powder. After conditioning in water at room temperature for 4 days, two test specimens were machined from each plate.

Results

The following table lists the significant deflections in millimetres of the test specimens under the designated loads.

Deflections in mms.

	Mottled Powder					Plain Powder				
	No.1	No.2	No.3	No.4	Mean	No.1	No.2	No.3	No.4	Mean
4000 grams load	2.54	2.08	2.36	2.01	2.25	2.59	2.13	2.92	2.31	2.49
6000 grams load	6.12	4.50	5.44	--[x]	5.35	7.04	4.57	----	5.18	5.60
Maximum load	6400	7000	6500	6000	6500	6300	7300	6000	7000	6600

[x] Failure caused by porosity in the specimen

Specifications: Maximum allowable deflection at 4000 grams load - 2.6 mm.
Deflection at 6000 grams load - 3 to 8 mm.
Maximum load - not less than 6000 grams.

In each of the two categories, plain and mottled, there is one borderline case. The mottled powder specimen which failed contained porosity. (We would like to indicate again that it is difficult to eliminate porosity entirely from Nuweld because of its rapid setting characteristics. The working time is all too often inconveniently short so that proper packing of the material in the mold cannot be achieved.) The plain powder specimens in general show a greater flexibility and a somewhat higher maximum strength. On the basis of these tests we would state that Nuweld denture base material meets the requirements for transverse strength.

January 6, 1949.

Douglas R. Christie
Research Fellow

APPENDIX "B"

ONTARIO RESEARCH FOUNDATION
Department of Chemistry

Dental Materials Research Fellowship

Report No. 4902 DR 21

Introduction

During the last year a research program has been conducted on problems connected with the repair of methyl methacrylate dentures.

This work was undertaken in an attempt to overcome the dimensional instability or distortion of dentures which so frequently results when they are repaired.

Distortion Caused by Repairs

There are essentially three types of repairs: replacement of one or more teeth, the welding of the separate pieces of a fractured denture and relining. Probably the most commonly used method to effect these repairs is to heat the invested denture for at least 9 hours, or more conveniently overnight, at a temperature in the range of 160-165°F. Under these conditions the denture undergoes a distortion which is almost without exception a contraction across the heels. As a result, the restoration will not accurately fit a cast or model of its original bearing surfaces and the occlusion of the teeth is similarly affected. This treatment causes a dimensional change of the order of 1/2 to 1 per cent.

It is not uncommon in some "rush" orders for dentures to be repaired by even more drastic methods involving the use of boiling water during some stage of the curing process. In this event, the dimensional change is about 1 per cent, and adaptation of the denture to its cast and occlusal index is non-existent. Table I shows quantitative data on dimensional changes produced in four denture blanks by heating at 160°F. for 6 hours and from room temperature to 212°F. in 2-1/2 hours.

TABLE I
Percentage Decrease in Dimensions

Denture	After 6 hr. at 160°F.		After 212°F.	
	Flange	Ridge	Flange	Ridge
1	.49	.44	.98	.87
2	.49	.44	.98	.88
3	.49	.45	.98	.89
4	.49	.44	.98	.89

It is a simple matter to show these distortions without actually preparing the denture for a repair. A cast and an occlusal index can be made of the original denture. Then all that is required is to invest the denture in a flask and heat it for, say, 1/2 hr. in boiling water or overnight at 160°F. The two treatments can be investigated with the same denture, provided a new cast and index are made after each "repair", for each subsequent heating produces additional distortion.

Repairs at Room Temperature

Recently several commercial brands of denture repair materials have been introduced. When used for repairs at room temperature, they do not reach, even after several weeks, the hardness of thermally cured methyl methacrylate but they quickly attain a strength sufficient to meet A. D. A. specifications. According to our tests it is possible to make a satisfactory repair with these materials but there is a tendency for porosity to occur when least expected or desired. The principle of making repairs at room temperature is quite sound and is to be commended but we are not aware that a material or method which is completely satisfactory is available as yet.

Repairs Requiring Heat Processing

As previously indicated, heat processing of dentures under repair at temperatures at or above 160°F. causes appreciable dimensional distortion. Experiments here have shown that a temperature range of 135 ± 2°F. should be used to make repairs. Temperatures slightly above this range cause slight distortion while the use of temperatures below this range necessitates a longer curing period.

(a) Overnight Curing at 135°F.

A great many dental laboratories follow the practice of making repairs by overnight processing at 160-165°F. This enables them to concentrate on necessary laboratory preparations during the day and the processing is completed without any special attention.

Safe processing without distortion of the denture can be conveniently accomplished by curing the new denture base material overnight or, in other words, for 16 hours at 135°F. The only precautions which need be carried out to obtain the most satisfactory polymer are (i) to remove the hydroquinone inhibitor from the monomer and (ii) to add approximately 0.1 per cent of benzoyl peroxide catalyst to the monomer just before mixing the monomer and the polymer. Where pre-mixed monomer-polymer gel is used these steps

obviously cannot be carried out. However, since it is claimed that pre-mixed gels have slightly higher transverse strengths than monomer-polymer mixtures, it should be possible to effect a satisfactory cure in 16 hours at 135°F. It should be pointed out that no quantitative information on hardness values or transverse strengths of gels have been obtained here. Table II gives Knoop hardness and transverse strength values of monomer-polymer mixtures cured by heating at 135°F. for 16- and 24-hour periods.

TABLE II

Monomer Used	Catalyst Used	Cure Time at 135°F.	Knoop Hardness	Transverse Strengths Deflections in mm. at 4000 gm.	6000 gm.	Av. Max. Load[3]
Lucitone	--	10 hr. at 160°F.	12.0	2.1	4.3	6900
"	--	24 hr.	13.8	2.5	6.1	6500
"	--	16 hr.	13.7	2.5	-	5850[2]
Inhibitor free	--	24 hr.	13.2	2.4	5.6	6700
"	--	16 hr.	12.3	2.4	5.9	6650
"	Benzoyl peroxide[1]	16 hr.	15.5	2.4	5.5	6750

1 - Concentration of this catalyst was 0.1% based on the weight of the monomer

2 - Failed to pass transverse strength test

3 - Deflection at 4000 grams must be less than 2.6 mm., at 6000 grams from 3-8 mm. and the average maximum load must be at least 6000 grams.

It will be seen from the figures above that it is necessary to remove the inhibitor to obtain satisfactory strength while the addition of the peroxide catalyst increases the hardness of the polymer.

The inhibitor can be removed by washing the monomer in a separating funnel with a 10 per cent aqueous solution of sodium hydroxide. The oxidation of hydroquinone is attended by a brown discoloration of the aqueous layer. Upon removal of this layer, the monomer is washed again two or three times with distilled water to remove the alkali and then dried thoroughly by the addition of plaster of Paris. After standing, with occasional agitation, over the drying agent for a short time, the monomer is filtered

obviously cannot be carried out. However, since it is claimed that pre-mixed gels have slightly higher transverse strengths than monomer-polymer mixtures, it should be possible to effect a satisfactory cure in 16 hours at 175°F. It should be pointed out that no quantitative information on hardness values or transverse strengths of gels have been obtained here. Table II gives Knoop hardness and transverse strength values of monomer-polymer mixtures cured by heating at 175°F. for 16- and 24-hour periods.

TABLE II

Monomer Used	Catalyst Used	Cure Time at 175°F.	Knoop Hardness	Deflections in mm. at Av. Max. 3000 gm.	6000 gm.	Load
Lucitone	--	16 hr. at 160°F.	12.0	2.1	4.3	6900
"	--	24 hr.	13.4	2.5	5.1	6500
"	--	16 hr.	13.7	2.5	-	5850
Inhibitor free	--	24 hr.	13.2	2.4	5.6	6700
"	--	16 hr.	12.3	2.4	5.3	6650
"	Benzoyl peroxide	16 hr.	15.5	2.4	5.5	6750

1 - Concentration of this catalyst was 0.1% based on the weight of the monomer

2 - Failed to pass transverse strength test

3 - Deflection at 6000 grams must be less than 5.6 mm., at 6000 grams from 3-6 mm. and the average maximum load must be at least 6000 grams.

It will be seen from the figures above that it is necessary to remove the inhibitor to obtain satisfactory strength while the addition of the peroxide catalyst increases the hardness of the polymer.

The inhibitor can be removed by washing the monomer in a separating funnel with a 10 per cent aqueous solution of sodium hydroxide. The oxidation of hydroquinone is attended by a brown discoloration of the caustic layer. Upon removal of this layer, the monomer is washed again two or three times with distilled water to remove the alkali and then dried thoroughly by the addition of plaster of Paris. After standing, with occasional agitation, over the drying agent for a short time, the monomer is filtered

and stored in dark-colored bottles. It may be stored safely at room temperature in this manner almost indefinitely without any indication of polymerization.

The repairing of dentures overnight at 135°F. is recommended for all types of repairs. Two common operations are rebasing and relining. Rebasing, as carried out by most dental laboratories, replaces almost all of the original denture base material except that supporting the teeth. It is most frequently encountered in connection with upper dentures. Under these circumstances, rebasing should probably be considered as the making of a complete new denture. Yet, because of the presence of some original denture base material in a most important area, it would be sound practice to follow the procedure outlined above for making repairs at 135°F. This is the only method which is recommended in this report for rebasing upper dentures.

Relining, most commonly performed on lower dentures, is distinct from rebasing in that only a small proportion of the original denture base material is replaced, For this reason, it can be thought of as a true repair.

It should be noted here that complete lack of distortion has not been obtained in the relining of lower dentures. The reasons for this are not clear but are probably due to the complicated shape of the denture and to the strong shrinkage forces which are set up during the polymerization of the added resin. Despite the lack of perfect dimensional stability in relining, in our experience this method is considerably superior to others which employ higher curing temperatures. It is evident that further work could be done on the relining problem.

(b) Repairs at 135°F. With Ultra-Violet Light

In order to complete repairs within the period of a working day, it was necessary to reduce the processing time to something approximating four hours. A comprehensive study of the polymerization of methyl methacrylate under the influence of ultra-violet radiations indicated that it is practicable to effect complete polymerization in this time.

Repairs of fractured dentures and the replacement of teeth can be carried out quite conveniently. The relining of lower dentures is not completely satisfactory by this method, although, here again, the method is as promising as any other. Methyl methacrylate can be polymerized by the action of intense ultra-violet radiations particularly those below 3000 Å. The polymerization is accelerated by increased temperatures and by certain light-activated catalysts which in turn activate the monomer molecules

by the transfer of absorbed energy. Benzoin is an example of this type of catalyst.

A few diagrams with brief explanations will explain the theory behind this repair method.

Curve 1, Figure 1, shows the ultra-violet transmission curve for clear methyl methacrylate polymer. Practically all the incident energy below 3000 Å is absorbed. Curve 2, Figure 1, shows the transmission curve for clear methyl methacrylate containing 0.1 per cent benzoin. Here, the absorption of energy has been increased by the amount shown between the two curves.

A study of the Knoop hardness values of methyl methacrylate is indicative of the degree of polymerization. In Figure 2 are curves showing the surface hardness values of pink methyl methacrylate plates 3 mm. thick after exposure to ultra-violet radiations at 135°F. and at approximately room temperature. Knoop hardness values were taken on both the ultra-violet exposed surface and on the unexposed surface after definite intervals of irradiation. At 135°F. both surfaces reach their maximum hardness after approximately 80 minutes. At room temperature about the same time is required but the maximum hardness never becomes as great as at 135°F. Figure 3 shows the hardness gradient developed in a 3-mm.-thick specimen after 1-1/2 hours' exposure to ultra-violet light.

In these experiments, the source of ultra-violet light was a 250-watt mercury vapor lamp designated as a UA 2 lamp by the Canadian General Electric Company. It was suitably installed in a stainless steel shield and preferably operated in a fume cupboard where the ozone produced during its operation could be carried away.

The following procedure is used in making denture repairs. The case is prepared and packed with new resin in the customary manner. It is preferable to use a monomer-polymer mixture which has had the inhibitor removed from the monomer and 0.1 per cent of both benzoin and benzoyl peroxide added to the monomer. The benzoyl peroxide serves as a thermal catalyst during the preliminary heat treatment which must be used before irradiation. The flask is placed in a water-bath at 135°F. for two hours during which time the new material is partially polymerized and assumes a fairly rigid condition.

At the end of the 2-hour preliminary heat treatment, the flask is opened to expose the area being repaired. If there are no undercuts, the flask may simply be separated into its two halves. If there are undercuts present and they usually occur when new material has to be added to

both the buccal and lingual sides of teeth, then the tooth-side of the investment must be cut away carefully until the teeth in question are free, whereupon the flask may be opened.

Clean off any adhering plaster from the area of new material but leave the rest of the lower half of the investment covering the denture.

The flask is now immersed in the water-bath at 135°F. once more. The water level should be at the rim of the flask and should not cover the new denture base material. The ultra-violet lamp is then placed about 6 inches from the flask and the denture irradiated for 1-1/2 hours. At the end of this time, the repair is finished and the denture may be removed and polished.

By this technique, dentures have consistently been repaired with no evidence of distortion. Perfect adaptation to casts and occlusal indices made before the repair was started can be obtained. The total processing time is only 3 1/2 hours.

(c) Trihexylamine and Infra-Red Radiations

One other rapid repair method has been worked out with considerable success. It is recommended only for fractures and the replacement of teeth.

The details of this method are quite similar to the ultra-violet technique. Instead of using a light-activated catalyst a thermal polymerization accelerator is used and the final rapid cure is obtained with an ordinary, commercial infra-red lamp of 250 watts.

The method makes use of a process first developed in Germany during the war. It was found that tertiary aliphatic and aromatic amines, in conjunction with benzoyl peroxide were powerful accelerators of the thermal polymerization of methyl methacrylate. The mechanism of the reaction is obscure, although it is believed that the tertiary amine oxide formed reduces the critical polymerization temperature. Tertiary aliphatic amines, such as trihexylamine are slower reacting but cause less discoloration than the tertiary aromatic amines, e.g., N,N-dimethylaniline. (A two per cent solution of dimethylaniline in methyl methacrylate will cause polymerization at room temperature in 15-20 minutes).

There has been some question about the use of tertiary amines in oral appliances or restorations in view of the fact that some of them may have toxic properties. As far

as we know there are no experimental data on this matter. It would appear unlikely that any adverse effects would result because relatively small quantities of these materials would be used in any case. It is a point, however, which should not be overlooked.

The monomer used in this method is free of hydroquinone inhibitor and contains 3 per cent trihexylamine. Before mixing with the polymer a small amount (about 0.5%) of benzoyl peroxide is added and dissolved.

The denture is prepared and packed as usual and the flask immersed in a water-bath at 135°F. for 2 hours. At the end of this time the flask is opened, observing the same precautions outlined in the ultra-violet method. The lower half of the investment is then covered with tinfoil, except for the exposed repair area, to act as a reflector of the infra-red radiations and to prevent the denture from being overheated. The repair is placed about 6 inches from a 250-watt infra-red lamp and exposed to its radiations for about five minutes. When the flask cools, the denture may be removed and polished. Processing time is therefore just over two hours.

Excellent results have also been obtained with this method except for the relining of lower dentures. In this case where the entire tissue-bearing surface of the denture must be exposed to the infra-red radiations there is a strong possibility that the relatively unsupported denture warps under the intense heat from the lamp.

There is a possibility of overcoming the relining problems in this method and in the ultra-violet method by taking the lining to a higher degree of polymerization before irradiation and by controlling or adjusting the radiation exposure time to suite the conditions. This might be the subject of further investigation.

Description of Photographs

Several photographs have been prepared to illustrate the text of this report. They are intended to convey as well as possible the adaptation of repaired dentures to their respective casts and occlusal indices which were made before the repairs were begun. It is difficult to show the occlusion of a denture on its index. However, the teeth on one side of a denture will fit the corresponding side of its index and those on the opposite side will not fit the opposite side of the index if there has been any distortion. It is possible, then to show the adaptation by photographing the teeth on one side of the denture when the teeth on the other are fitting the index properly. Any gap between the teeth and the index in the photograph will be a qualitative indication of distortion. If there is excellent adaptation to the cast, there is always a good fit on the occlusal index.

The dentures which were relined were photographed on a brass master model. The actual processing of the relines was done on artificial stone casts which were duplicates of the brass model.

Table III summarizes the information shown in the photographs.

TABLE III

Photograph	Repair Conditions	Type of Repair	Remarks
Fig. 4	6 hr. at 160°F. (left) 1/2 hr. at 212°F. (right)	Replace teeth	Serious distortion Poor cast adaptation.
Fig. 5	6 hr. at 160°F.	" "	Change in occlusion shown by shadows between teeth and index.
Fig. 6	1/2 hr. at 212°F.	" "	Severe change in occlusion
Fig. 7	2 separate repairs in each denture - 16 hr. at 160°F. (left) U.V. and I.R. (right)	Fracture and replace teeth	Severe distortion - poor cast adaptation (left) No distortion - excellent cast adaptation (right)
Fig. 8	2 repairs - 16 hr. at 160°F.	Fracture and replace teeth	Severe change in occlusion
Fig. 9	2 repairs - U.V. and I.R. methods	Fracture and replace teeth	No change in occlusion
Fig. 10	16 hr. at 135°F. (left) I.R. method (right)	Replace teeth Fracture	No distortion - excellent cast adaptation
Fig. 11	16 hr. at 135°F.	Replace teeth	No change in occlusion
Fig. 12	Ultra-violet method	Reline	Serious distortion - poor cast adaptation
Fig. 13	16 hr. at 165°F.	Reline	Serious distortion - poor cast adaptation
Fig. 14	16 hr. at 135°F.	Reline	Slight distortion fair cast adaptation
Fig. 15	16 hr. at 160°F.	Reline	Serious change in occlussion
Fig. 16	16 hr. at 135°F.	Reline	Slight change in occlusion.

March 1, 1949.

Douglas R. Christie,
Research Fellow.

The dentures which were refined were photographed on a brass master model. The actual processing of the refines was done on artificial stone casts which were duplicates of the brass model.

Table III summarizes the information shown in the photographs.

TABLE III

Photographs	Repair conditions	Type of Repair	Remarks
Fig.4	6 Br.at 160°F.(left) 1/2 Br.at 212°F.(right)	Replace teeth	Serious distortion Poor base adaptation.
Fig.5	6 Br.at 160°F.	" "	Change in occlusion shown by shadows between teeth and ridges.
Fig.6	1/2 Br.at 212°F.	" "	Severe change in occlusion
Fig.7	2 separate repairs to fracture and each denture - 16 Br.at 160°F.(left) U.V. and I.R.(right)	Replace teeth	Severe distortion - poor base adaptation (left) No distortion - excellent adaptation (right)
Fig.8	2 repairs -16 Br.at 160°F.	Fracture and replace teeth	Severe change in occlusion
Fig.9	2 repairs - U.V.and I.R. methods	Fracture and replace teeth	No change in occlusion
Fig.10	16 Br.at 135°F.(left) I.R.method (right)	Replace teeth Fracture	No distortion - excellent base adaptation
Fig.11	16 Br. at 135°F.	Replace teeth	No change in occlusion
Fig.12	Ultra-violet method	Refine	Serious dis-
Fig.13	16 Br.at 160°F.	Refine	portion - poor base adaptation
Fig.14	16 Br. at 160°F.	Refine	Serious dis- portion - poor base adaptation Slight distortion Fair base adaptation
Fig.15	16 Br. at 160°F.	Refine	Serious change in occlusion
Fig. 16	16 Br. at 135°F.	Refine	Slight change in occlusion
Bench 1	1049	Duplicate Cast	

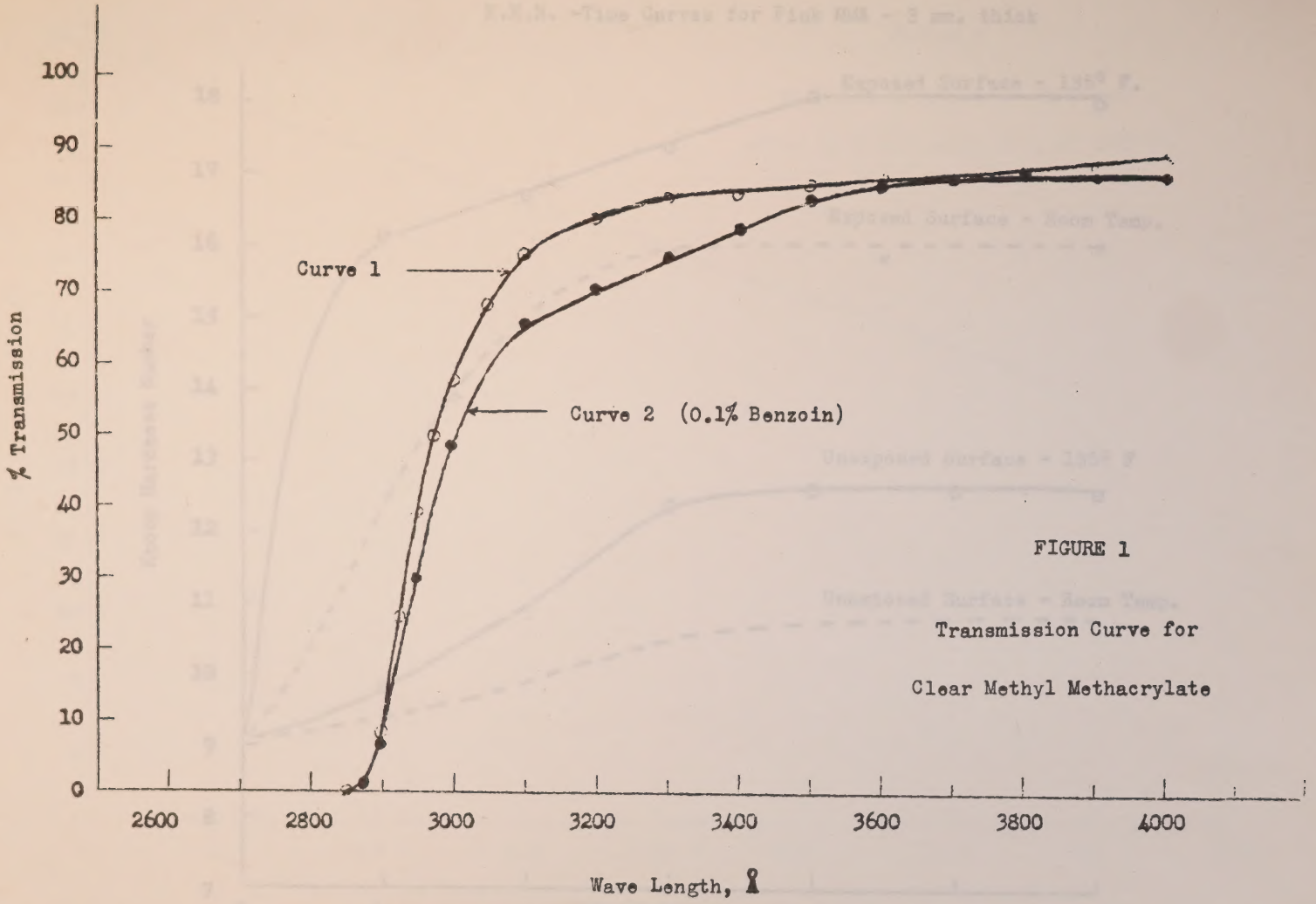


FIGURE 1

Transmission Curve for

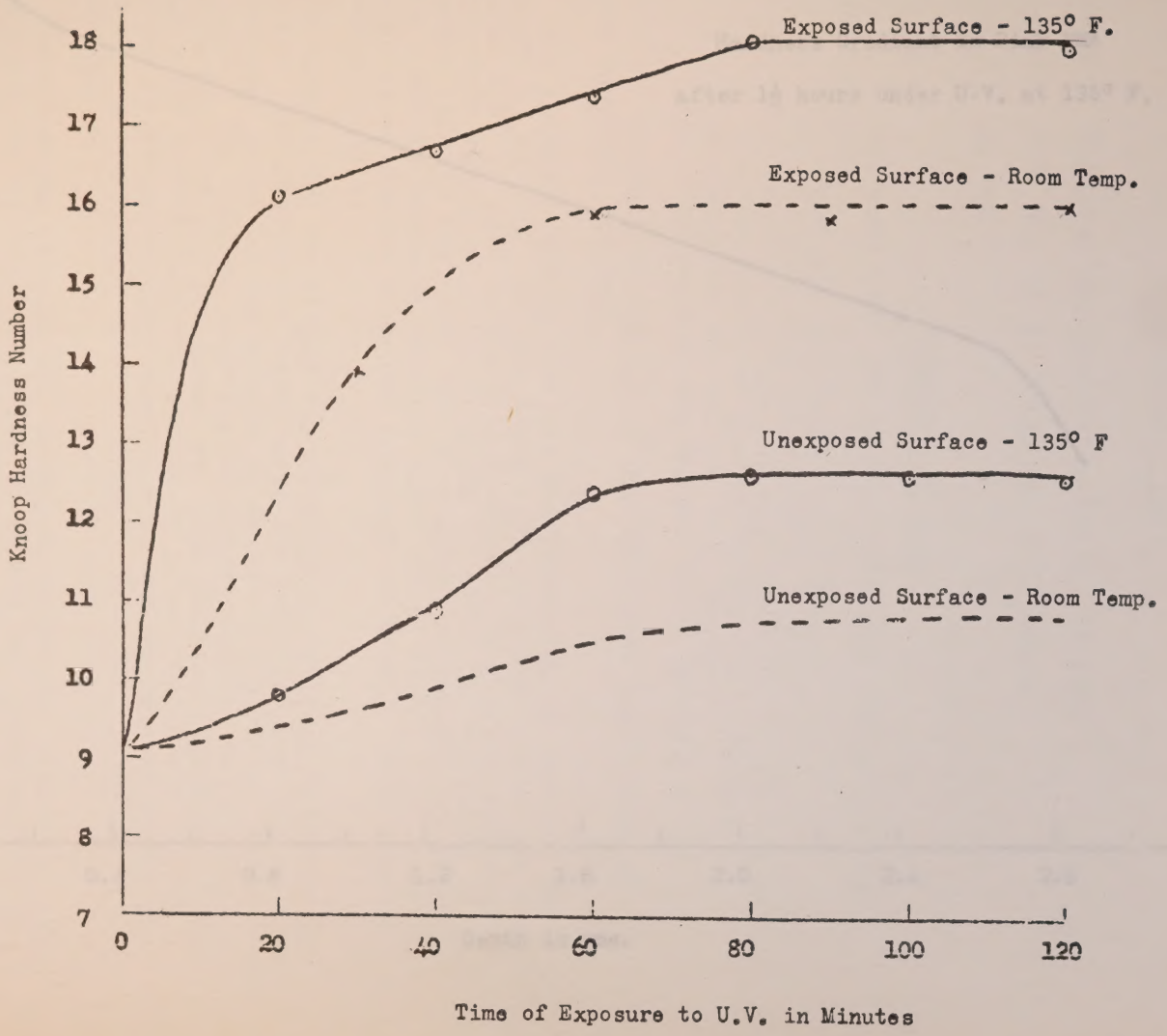
Clear Methyl Methacrylate

FIGURE 1

Transmission Curve for
Oleic Methyl Benzoinstarate

FIGURE 2

K.H.N. -Time Curves for Pink MMA - 3 mm. thick



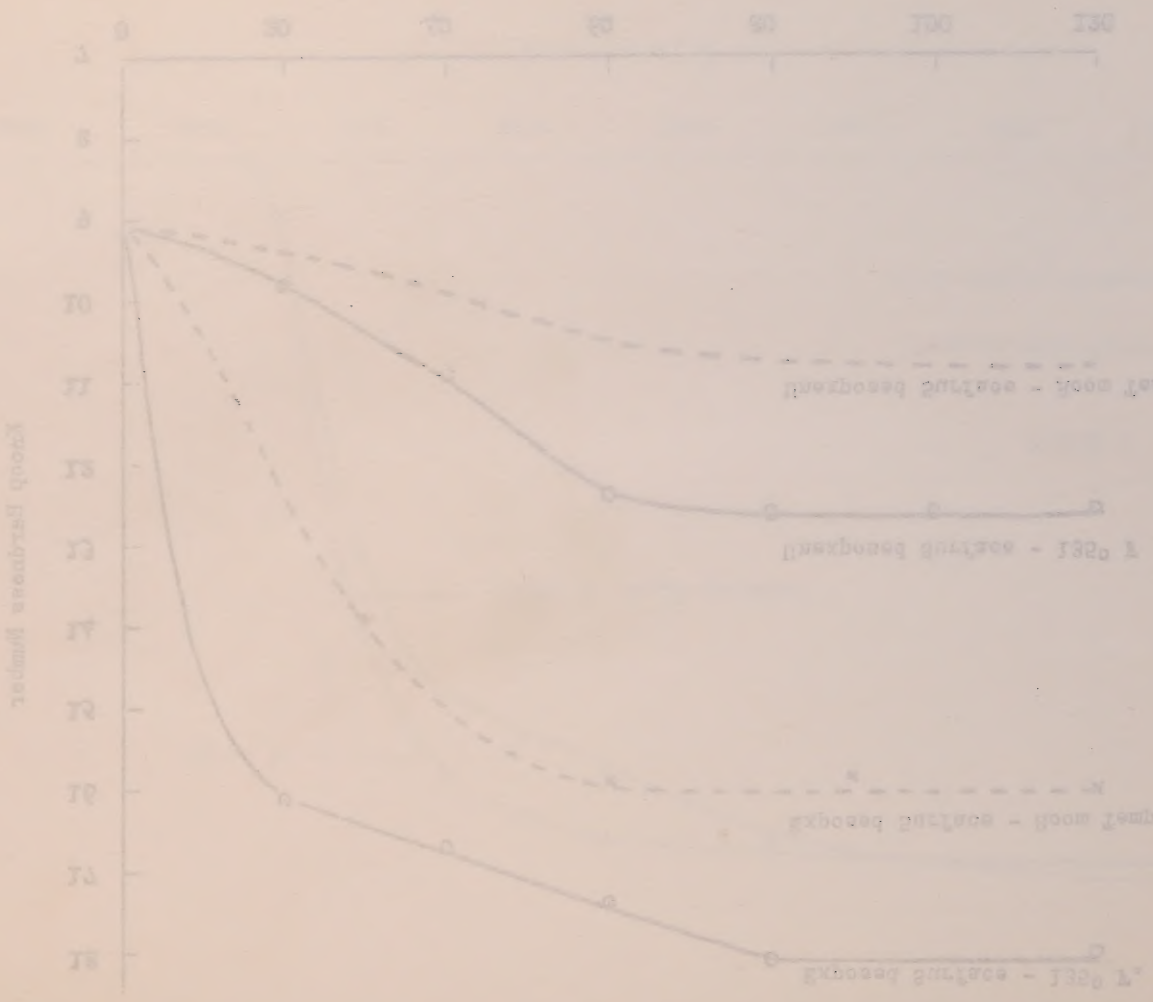
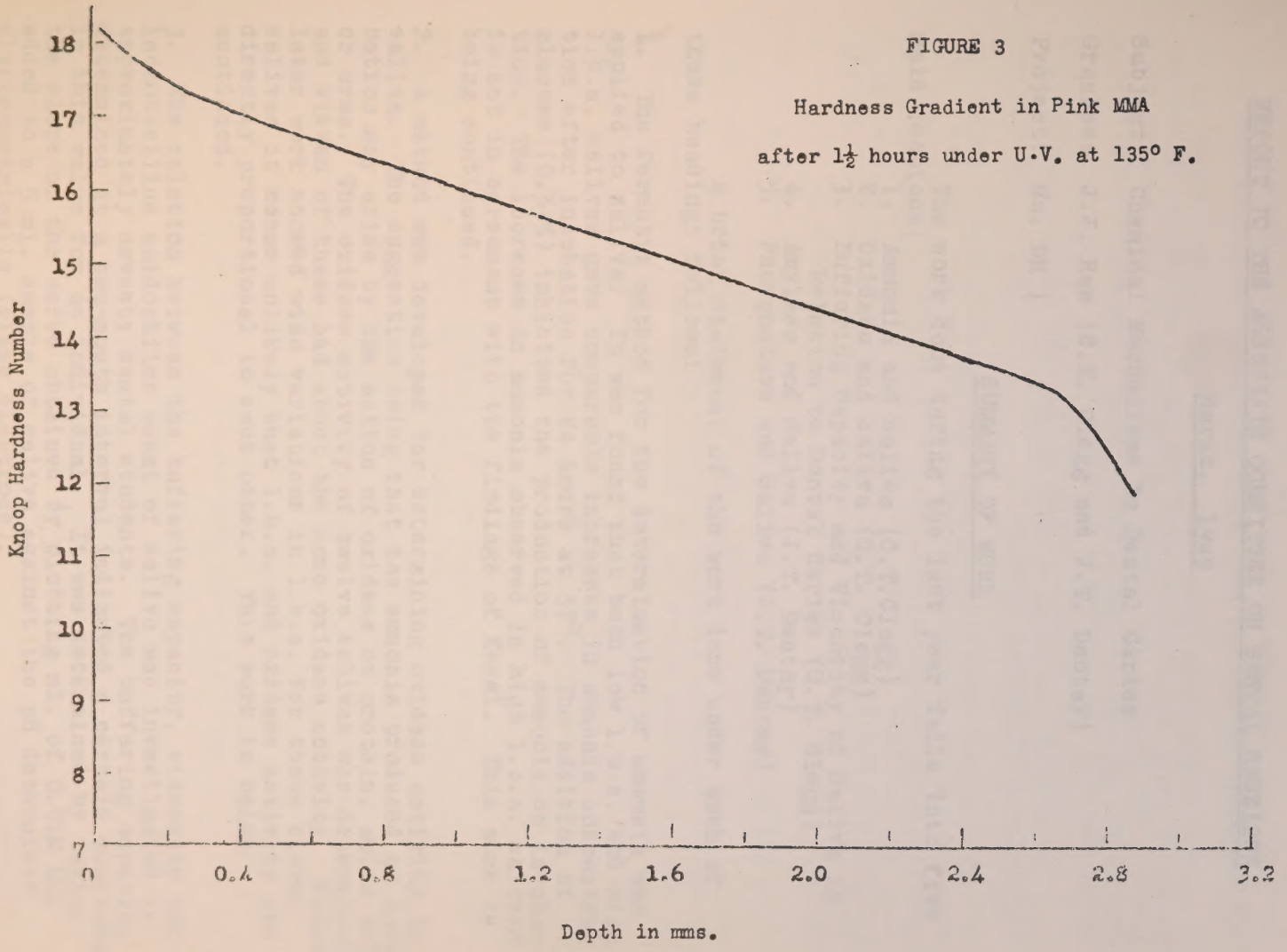


FIGURE 3

Hardness Gradient in Pink MMA

after 1½ hours under U.V. at 135° F.



APPENDIX "C"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Chemical Mechanisms in Dental Caries

Grantee: J.J. Rae (C.T. Clegg and J.T. Dentay)

Project: No. DR 1

SUMMARY OF WORK

The work done during the last year falls into five main sections:

1. Ammonia and Saliva (C.T.Clegg)
2. Oxidase and Saliva (C.T. Clegg)
3. Buffering Capacity and Viscosity of Saliva in Relation to Dental Caries (C.T. Clegg)
4. Amylase and Saliva (J.T. Dentay)
5. Phosphatase and Saliva (J.T. Dentay)

A brief statement of the work done under each of these headings follows:

1. The Permutit method for the determination of ammonia was applied to saliva. It was found that both low l.b.a. and high l.b.a. salivas gave comparable increases in ammonia concentration after incubation for 24 hours at 37°. The addition of glucose (0.33%) inhibited the production of ammonia on incubation. The increase in ammonia observed in high l.b.a. salivas is not in agreement with the findings of Kesel. This work is being continued.

2. A method was developed for determining oxidase activity in saliva. The suggestion being that the ammonia produced on incubation may arise by the action of oxidase on protein, amino acids or urea. The oxidase activity of twelve salivas was determined and eleven of these had about the same oxidase activity. Since later work showed wide variations in l.b.a. for these eleven salivas it seems unlikely that l.b.a. and oxidase activity are directly proportional to each other. This work is being continued.

3. The relation between the buffering capacity, viscosity and lactobacillus acidophilus count of saliva was investigated in approximately seventy dental students. The buffering capacity determined at a two-month interval indicated a certain constancy in this value for an individual. It was determined by taking the slope of the curve obtained by plotting ml. of 0.01M HCl added to a 5 ml. sample of saliva against the pH determined electrometrically (glass electrode).

No positive rank correlation was observed between the buffering capacity and the lactobacillus acidophilus count.

The viscosities were remarkably uniform and showed no positive rank correlation with the lactobacillus acidophilus count. Our thanks are due to two members of the Faculty of Dentistry, Dr. W. McIntosh who supplied the saliva and Miss Berry who did the bacterial counts.

Permission is being sought to publish these results in the Journal of Dental Research.

4. The amylase activity of salivas is influenced a great deal by the chloride concentration. To compare amylase activities in different salivas it is necessary to compare them at the same chloride concentration by reference to a graph relating chloride concentration and amylase activity. When this was done no relationship could be observed between amylase activity and the degree of dental caries.

Permission will be sought to publish these results.

5. A paper has been accepted for publication in the Journal of Dental Research entitled "Phosphatase in Saliva". In it, it was shown that there is no phosphatase in cell-free, filtered saliva; that Lactobacillus acidophilus in saliva contributes only very small amounts of phosphatase and that the origin of the phosphatase in the saliva is probably cellular debris and food residues.

1 February, 1949

APPENDIX "C"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Chemical Mechanisms in Dental Caries

Grantee: J.J. Rae (C.T. Clegg and J.T. Dentay)

Project No.: D.R. 1 Amount of Grant: $ 1150.00

INTERIM REPORT NO. 7

Period Covered - February 8, 1948 - February 8, 1949

The work done during this period falls into five

1. Ammonia and Saliva
2. Oxidase and Saliva
3. Buffering Capacity and Viscosity of Saliva in Relation to Dental Caries
4. Amylase and Dental Caries
5. Phosphatase

1. Ammonia and Saliva

In continuation of the work mentioned in our last report, the estimation of ammonia by the Permutit method of Folin and Bell (J.B.C. 29, 329, 1917) as adapted to saliva by Karshan (J.D.R. 15, 325, 1935), was investigated.

In this method 1 gm. of Permutit is added to 3 cc. of saliva and 2 cc. of water, and the mixture shaken for 5 minutes. The Permutit was washed with 15 cc. portions of water and then treated with 1 cc. of 10% NaOH, shaken for 20 minutes, water and 2.5 cc. of Nessler's reagent solution added to make volume up to 50 ml. After standing 10 minutes, the colour is compared in the Lumetron with a standard ammonium sulphate solution.

The ammonia produced on incubation for 24 hours at 37° C. of two groups of saliva:- (A) with low l.b.a. counts; and (B) with high l.b.a. counts are shown in Table I.

TABLE I

Production of Ammonia in Saliva on Incubation

mg % Ammonia

	0 Hours	24 Hours	Difference
(A)	1.29	38.6	37.3
(High l.b.a.)	6.18	51.5	45.3
	20.6	54.0	33.4
	1.29	19.1	18.8
	9.95	42.8	32.8
(B)	10.32	39.8	29.5
(Low l.b.a.)	8.38	28.4	20.0
	7.74	31.0	23.3
	2.5	30.8	28.3

There seems to be slightly more ammonia production in the caries immune-group but the series is too restricted and the difference too slight to give support to Kesel's contention that caries-susceptible salivas produce little or no ammonia on incubation.

The addition of 0.33% glucoseinhibited the ammonia production by one day's incubation at 37°.

The extent and mechanism of this inhibition is being investigated and it is hoped to shed more light on the nitrogen compounds in saliva in future work on this phase of the research.

2. Oxidase in Saliva

If there is more ammonia produced in caries-immune than in caries-susceptible saliva on incubation, as observed by Kesel, this ammonia could be produced by oxidation of the protein or amino acids in saliva. Oxidase is an enzyme present in saliva (Pincus - Br.D.J. 181, 1942) which might be responsible for this ammonia production. If so, caries-immune saliva should exhibit more oxidase activity than caries-susceptible saliva.

The method used for measuring oxidase activity in saliva was modified from the method of (Snell - Colorimetric Analysis, Vol. II, p. 602) - 3 cc. of saliva and 3 cc. of water was centrifuged for 10 minutes. To the centrifugate was added the following 3 reagents, previously mixed:

1. 2 cc. of 0.18% alpha-naphthol in a 1:1 solution of water and 95% alcohol.

2. 2 cc. of 0.216% aqueous solution of dimethyl-p-phenylenediamine hydrochloride.

3. 1 cc. of 0.31% aqueous solution of sodium carbonate.

A blank was prepared by mixing 5 cc. of the mixed reagents with 6 cc. of water.

The color developed was measured on the Lumetron after exactly 20 minutes.

It was found that boiled saliva contained no oxidase and that saliva incubated for 16 hours decreased in oxidase activity by 50%. The amount of oxidase present in the precipitate from centrifuged saliva is very small.

Oxidase activity on a series of salivas were determined. Salivas after treatment with acid to determine buffering capacity and subsequent neutralization showed a considerable decrease in oxidase activity. There seems to be no clearly defined optimum pH for oxidase, using this method, provided that the solution is alkaline.

3. The Relation Between Buffering Capacity, Viscosity and Lactobacillus Acidophilus Count of Saliva.

A copy of this section was sent in with a request for permission to publish this in the Journal of Dental Research a few days ago.

4. Amylase and Dental Caries

On the assumption that enzymes might play an important part in the carious process we were interested in seeing if there was a relation between amylase and dental caries. A survey of the literature yielded conflicting reports. A standard method for determining amylase activity was developed. It was an adaption of Wohlegemuth's colorimetric method in which the dextrinizing power of amylase is measured using a dextrin-iodine endpoint. Since chloride ion is necessary for the hydrolysis of starch by amylase and since the chloride concentration affects amylase activity, it was necessary to determine chloride ion concentration of all the salivas used. Schales and Schales (J.B.C. 140, 979, 1941) blood microvolumetric method was found to be the most satisfactory. To obtain a curve showing the relation between salivary amylase activity and chloride concentration it was necessary to dialyse saliva

free of chloride, add known increments of sodium chloride, and determine the amylase activity at these various chloride concentrations.

The amylase activity and chloride concentration of approximately 150 salivas was determined using these methods.

The results indicate that there is no relation between dental caries and amylase activity. The amylase content(i.e. amylase activity rectified by reference to the chloride concentration of the saliva concerned) also shows no relation to dental caries.

5. Phosphatase in Saliva

A copy of this section was sent in with a request for permission to publish in the Journal of Dental Research. It was appended to our Progress Report No. 6.

APPENDIX "D"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Corrosion of Dental Materials by Cleaning Agents

Grantee: Dr. O.J. Walker and Dr. H.R. MacLean

Project No. DR 9 Amount of Grant: $1,000

SUMMARY OF WORK

Corrosion measurements have been made on samples of Denchrome, Durallium, Vitallium, and Ticonium in solutions of Polident, Sterakleen and Hygeol. Test pieces made by soldering different alloys together with 18K gold were also tested.

All alloys and alloy combinations tested have proven to be very resistant to corrosive attack by saturated solutions of Polident and Sterakleen. These two cleaning agents are thus considered to be non-corrosive for all practical purposes.

Hygeol has been shown to attack simple samples of Denchrome and Ticonium, and all soldered samples. In some cases, the corrosive attack on joined samples occurs at the soldered connection, but in most cases, the more corrodible (less resistant) alloy is the seat of the main attack.

Some photographs are submitted to illustrate some interesting results obtained.

1 February, 1949

(sgd.) Dorothy E. Coggles,
Research Assistant.

APPENDIX "D"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Corrosion of Dental Materials by Cleaning Agents

Grantee: Dr. O.J. Walker and Dr. H.R. MacLean

Project No.: DR 9 Amount of Grant: $1000.00

The measurements of the corrosion of some dental alloys and alloy combinations as outlined in previous reports to this committee has been continued as scheduled. As before, the alloys under consideration are Denchrome, Durallium, Ticonium and Vitallium, and the cleaning agents used to date on the tests are Sterakleen, Polident and Hygeol.

The method of procedure for the actual experimental work has not been changed since the last report--that is, the test pieces are cleaned by washing for one minute in concentrated hydrochloric acid, fifteen minutes in distilled water, five minutes in alcohol, five minutes in ether and then dried for one hour and weighed to 0.0001 grams. After weighing, the test pieces are suspended by means of paraffin-dipped thread into Erlenmeyer flasks containing 250 ml. of the corrosion medium. The flasks are suspended into a thermontically controlled water bath in which the temperature is maintained at 50°C ± 1°C. The test pieces are left in the hot solution for thirty day periods during which the flasks are shaken manually each morning. At the end of this period, the samples are removed from the flasks and cleaned in the manner used for their preparation. After weighing, the loss in weight of the sample is determined, and from this and the original weight of the test piece, the percentage corrosion is calculated.

Since the last report, photographs have been taken to illustrate some of the types of corrosion which have been encountered. In this regard, photographs I and II show simple test pieces which have been used in some of our experiments.

I Sample of Denchrome (Stainless Steel)

This sample shows the effect of a solution of Hygeol, undiluted, on a test sample of Denchrome, after exposure of 743.5 hours. Note the extensive corrosion along one side resulting in complete disintegration of the metal. Note also that the corrosion seems to occur along a straight line. This linear style of corrosion was shown on other samples of Denchrome after exposure to Hygeol and may be rather characteristic.

II Sample of Ticonium

This sample shows the effect of an undiluted solution of Hygeol on a Ticonium test piece after exposure of 743 hours. One should note the somewhat extensive pitting of the surface. This pitting seems to be characteristic of the corrosive effects of various media on the Ticonium test pieces.

It will be recalled that, at the time of the last report, tests on samples of these alloys soldered together with 18K gold solder had just been started. This type of test has been continued and it is the object of this paper to report on the corrosion of some of these samples in undiluted and diluted Hygeol and in saturated solutions of Sterakleen and Polident. The results are summarized in the following tables:

Table I Corrosion in Undiluted Hygeol

Test Piece	Time of Exposure to Hygeol (hours)	Original wt. of test piece(grams)	Loss in weight (grams)	Corrosion Loss in Percent
Durallium-Durallium	336	1.4530	0.0281	1.94
Durallium-Durallium	336	1.3894	0.0204	1.47
Durallium-Vitallium	336	1.4499	0.0164	1.13
Durallium-Vitallium	336	1.4244	0.0226	1.59
Durallium-Denchrome	336	0.8742	0.0603	6.90
Durallium-Denchrome	336	0.9968	0.0681	6.83
Durallium-Ticonium	336	1.7190	0.0997	5.80
Durallium-Ticonium	336	1.7678	0.0824	4.66

Several photographs of samples used in the above tests are submitted. These samples have been chosen to illustrate several methods of corrosive attack by Hygeol on the various dental alloys combinations.

III Samples of Durallium and Ticonium joined by 18K gold solder.

This test piece was prepared by soldering together simple test pieces of Durallium and Ticonium using an 18K gold solder. It is to be noted that the solder itself, and its junctions with the test pieces are not attacked after 336 hours in Hygeol, but that pitting occurs to some extent on both individual pieces. As was expected, the pitting of the Ticonium was much more extensive than that of the Durallium test piece.

IV Samples of Durallium and Denchrome joined by 18K gold solder

This sample of Denchrome and Durallium shows extensive corrosion of the Denchrome part after 336 hours exposure to undiluted hygeol. Note that the Durallium is almost unaffected, whereas the Denchrome is badly corroded away, especially immediately under the solder.

V Samples of Durallium and Vitallium joined by 18K gold solder

This test piece was exposed to undiluted Hygeol solution for 336 hours. In this case, the corrosive attack of the solution seems to have been centred on the join which has disintegrated to the extent that the metals are separated. The samples may be seen placed together in (V) and one bad pit in the gold is evident. In (Va), the samples are shown apart and the end of the pit through the gold is shown on the Vitallium test piece. This attack at the join, resulting in separation of the two pieces, seems to be rather characteristic of the effect of Hygeol on test pieces made up of these two rather resistant alloys.

VI Samples of Durallium and Vitallium joined by 18K gold solder

This sample shows again the attack at the junction of the two dissimilar alloys after 336 hours treatment with Hygeol. There is, however, no apparent pitting of the gold solder in this case. The Vitallium test piece seems to be rather badly discolored.

VII Samples of Durallium and Ticonium joined by 18K gold solder

This sample shows again an attack on the test pieces. Both the Durallium and Ticonium test pieces show pitting, whereas the gold solder seems to be only slightly affected after 336 hours exposure to Hygeol. As usual, the corrosion is more extensive on the Ticonium test piece.

Table II Corrosion in Saturated Sterakleen Solution

Test Piece	Time of exposure to Sterakleen solution (hours)	Original wt. of test pieces (grams)	Loss in weight (grams)	Corrosion Loss in Percent
Ticonium-Ticonium	743.5	1.9932	0.0024	0.12
Vitallium-Vitallium	743.5	1.7506	0.0004	0.02
Vitallium-Denchrome	743.5	1.3641	0.0002	0.01
Vitallium-Durallium	743.5	1.7379	0.0006	0.03

It will be observed that the test piece combinations are almost as resistant to saturated Sterakleen solution as they were to the individual alloys. In all cases, the surfaces of the test pieces and the gold solder were still shiny, and the only noticeable effect of the treatment was a slight discoloration of the samples. Photograph VIII is included to exemplify this class.

VIII Sample of Vitallium and Denchrome joined by 18K gold solder

This sample of Vitallium and Denchrome test pieces soldered together by an 18K gold solder has been exposed to a saturated solution of Sterakleen for 743.5 hours. It is included to illustrate those samples which show little or no corrosion. Close examination shows the only important physical change to be a slight discoloration of the sample. It is pointed out that one of the components is stainless steel which has been shown to be the least resistant of all the alloys tested.

Table III Corrosion in Saturated Polident Solution

Test piece	Time of exposure in Saturated Polident Solution (hours)	Original wt. of test pieces(grams)	Loss in weight (grams)	Corrosion Loss in Percent
Ticonium-Ticonium	743.5	1.8107	0.0011	0.06
Vitallium-Vitallium	743.5	2.2373	0.0002	0.01
Vitallium-Denchrome	743.5	1.1046	0.0000	0.00
Vitallium-Durallium	743.5	1.2826	0.0000	0.00

Table IV Corrosion in Diluted Hygeol (35 mo. Hygeol in 2000 ml. H_2O)

Test piece	Time of exposure to Hygeol(hours)	Original wt. of test pieces(grams)	Loss in weight (grams)	Corrosion Loss in Percent
Denchrome-Denchrome	761.5	0.5300	0.0061	1.15
Denchrome-Vitallium	761.5	1.1914	0.0115	0.96
Vitallium-Vitallium	761.5	1.5816	0.0026	0.16
Durallium-Durallium	761.5	1.0202	0.0047	0.46
Ticonium-Denchrome	761.5	1.1784	0.0027	0.23
Durallium-Vitallium	761.5	1.5929	0.0028	0.18
Durallium-Denchrome	761.5	1.3374	0.0636	4.75
Durallium-Ticonium	761.5	0.8605	0.0313	3.64

The tests summarized in Table IV were not completed until February 10, 1949, - too late to be photographed for this paper.

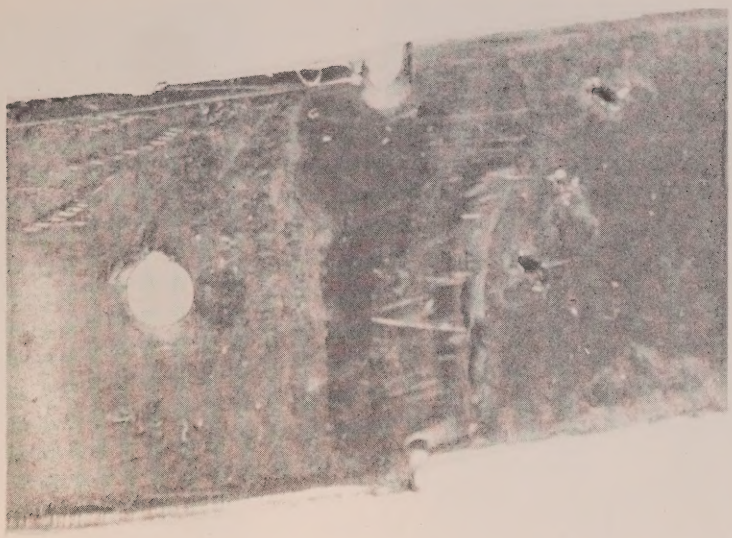
On the basis of the results obtained so far, it seems safe to conclude that Polident and Sterakleen make no aggressive corrosive attack on common dental alloys, but that Hygeol does attack these alloys to varying extents. On this basis, the investigators feel that tests using Polident and Sterakleen as the corrosion media should be discontinued, but that more work should be done with Hygeol.

I Denchrome corroded by Hygeol.

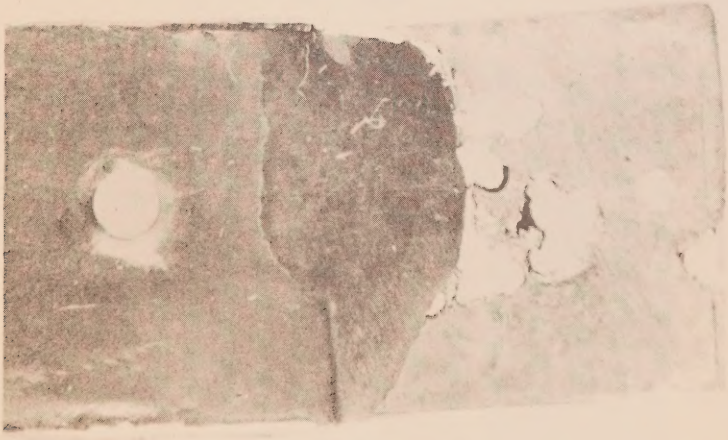
II Ticonium corroded by Hygeol

— both samples show pitting

III Durallium - Ticonium corroded by Hygeol

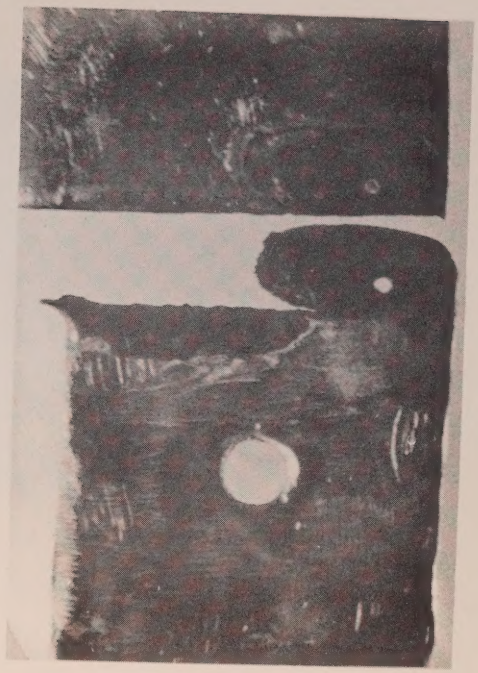


IV Durallium - Denchrome corroded by Hygeol

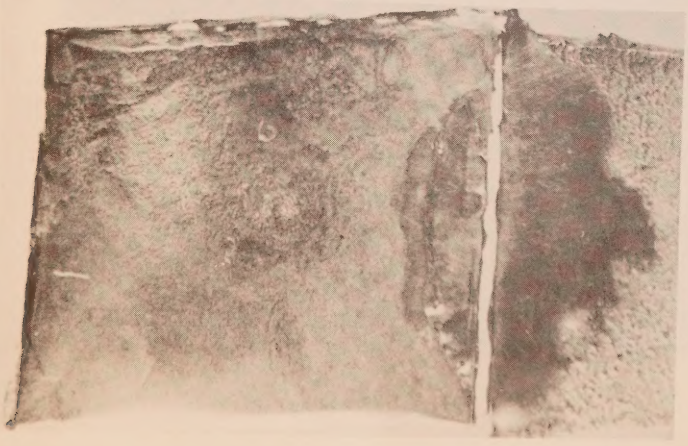


- note corrosive attack on one test piece

V . VA Durallium - Vitallium corroded by Hygeol

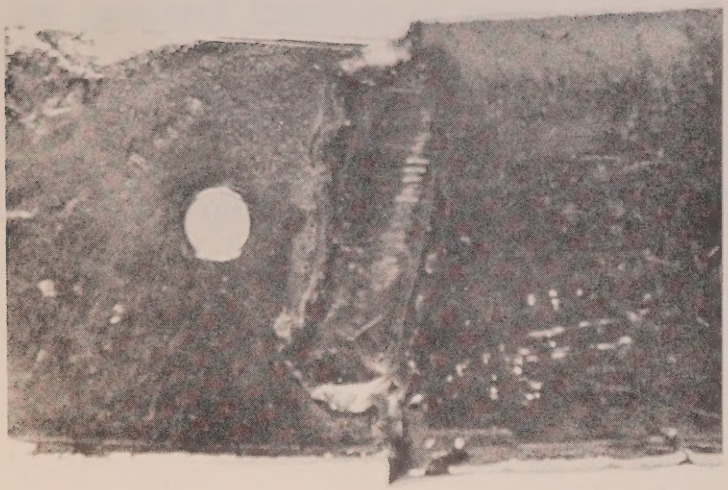


VI Durallium - Vitallium corroded by Hygeol



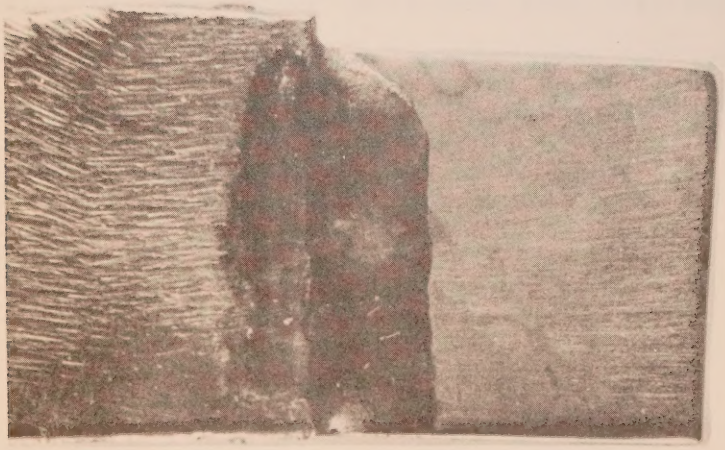
- note corrosive attack at soldered joints

VII Durallium - Ticonium corroded by Hygeol



-pitting.

VIII Vitallium - Denchrome corroded by Stera-Kleen



-negligible corrosion - discoloration.

APPENDIX "E"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: In vivo studies of certain fungus-like micro-organisms found in periodontal disease.

Grantee: C.H. Best

Project No.: D.R. 16 Amount of Grant: $1500.00

SUMMARY OF WORK

A summary was presented in the preceding report, of experiments in which we were able to demonstrate the occurence and development of the fungus-like organism Leptothrix falciformis in surgically induced periodontal pockets in dogs. This work has been continued but no new facts have been obtained.

Most of Mr. O'Connell's time has been devoted to assisting and co-operating with Dr. W.J. Linghorne in carrying out the work of Project D.R. 22.

C.H. Best
Signature

Date: January 18, 1949

APPENDIX "E"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

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Date: January 18, 1949

C.H. Best
Signature

APPENDIX "E"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: In vivo studies of certain fungus-like micro-organisms found in periodontal disease.

Grantee: C.H. Best

Project No.: D.R. 16 Amount of Grant: $1500.00

A study of the microscopic fungus-like organism Leptothrix falciformis has been continued. As mentioned in the interim report, it was possible to study the presence and to a degree the development of this organism in surgically induced periodontal pockets under controlled conditions. These experiments have been enlarged upon somewhat but we have been unable to follow to our satisfaction the complete development of the organism in the pocket.

The growth processes in the life-cycle of the Leptothrix falciformis occur so rapidly in the pocket that it seems impossible to observe the steps at the beginning and to follow the cycle through to the mature fungus-like form which is so commonly seen in smears from established pockets.

However after careful study of stained smears of material taken at intervals from pockets after sterilization, we have made certain observations which may be of importance to this project and certainly merit further investigation.

After the sterilizing periodontal pack is removed, and the pocket is left untouched for several days, smears will show very few, if any, organisms of the fusospirochetal group. However, if a smear is taken by inserting a tapered tooth pick into the pocket within 24 - 48 hours, the subsequent smears taken after daily intervals usually show greatly increased numbers of fusospirachetal organisms, including fungus-like processes of the Leptothrix falciformis. This finding was also observed when a normal gingival crevice was probed for measurement prior to surgical procedure in the normal mouth of a dog.

These observations would indicate that very minor irritation or injury of the gingival epithelium was sufficient to bring about a change in the bacterial flora of gingival crevices.

When surgically induced pockets are made on upper cuspid teeth in dogs, the fusospirochetal infection which results has an influence on the bacterial flora of the gingival crevices of other teeth in the mouth, particularly those of the lower cuspid teeth. This effect on untouched crevices in the mouth will be studied in greater detail under controlled conditions. If it proves to be fact it would definitely support the theory of Primary Incubation Zones suggested by Dr. H.K. Box in his monograph "Necrotic gingivitis".

In the study of the mechanism of repair of the supporting tissues of the teeth following surgical detachment, smears of material from the existing gingival crevices have been made and microscopic observations recorded. This study has not been completed but certain facts have been learned which are of great interest.

The fusospirochetal flora of crevices which persist for a short time in relation to re-attaching flaps is almost negligible whereas the flora of crevices of flaps which fail to re-attach increases in number almost immediately after the effects of acute inflammation begin to pass away. Even though fusospirochetal organisms exist in the mouth at all times, they do not appear in the crevices of re-attaching flaps. These flaps at the same time have been subjected to the same processes of infection and inflammation as those flaps which failed to re-attach; therefore it would seem that the processes of natural healing and repair are able to inhibit the usual fusospirochetal flora found in areas which are subject to inflammatory injury. It is possible for healing and repair of the supporting tissues of the teeth to take place in the presence of infecting organisms without the immediate area being influenced to any great degree by these organisms.

This fact is difficult to understand when it is known that there is an increased number of fusospirochetal organisms at the sites of mechanical injury of a very minor nature. Future studies are being considered in order to interpret these contradictory findings.

APPENDIX "F"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Improvement of Sub-Gingival curettage and Gum resection used in the treatment of the Periodontal pocket.

Grantee: Jules Thébaud

Project No.: DR-20 Amount of Grant: $ 750.00

SUMMARY OF WORK

1. Curetting of the cemental wall - Scaling and finishing were performed on 36 extracted teeth in order to replace 2 series of specimens which were not suitably prepared by our technician, as it was explained in our report No. 2 of October 1948. Our findings, following the microscopic study are shown with microphotographs and histological details in a special table, which is submitted with our final report.

The same investigation, with different tests is now being conducted in the mouth, on teeth involved with pathosis.

2. Curettement of the soft tissue at the Periodontal wall - In trying to eliminate the disorganized layers of epithelial cells on the soft side of the periodontal pocket, we are experimenting with a special scraper. Primary results have been recorded on microphotographs. Other biopsy materials taken from the marginal gum are actually under preparation.

3. Curettement of the bottom of the Periodontal pocket - Due to the difficulty in obtaining biopsy materials regarding this part of our investigating task, we have performed a deep curettage with our broach-type curette and the specimen is under decalcifying process since November last.

- - - - - - - -

4. Improved technique for Gum resection (Gingivectomy) - In order to complete the second part of our project, we have devoted a considerate amount of time to devise an original armamentarium and also to outline and try a new and improved technique for gingivectomy. Complete details with histological comments and the general outline of our technique are submitted in our final report with the presentation of 15 newly devised instruments manufactured by the S.S. White Company, Varsity Dental Mfg. Company and Halliburton & White.

When intensible practice and critical analysis of this part of our project will convert it to a more precise and a more simplified technique, we shall be able to devote most of our time to the first part of our investigation, that is, to attempt to find improved procedures for the subgingival method.

APPENDIX "F"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

APPENDIX "F"

To: The Chairman of the Associate Committee on Dental Research.

Via: Mr. S. J. Cook, Secretary,
Associate Committee on Dental Investigations,
National Research Council,
Ottawa, Canada.

Grantee: Dr. Jules Thébaud,
270 Outremont Avenue,
Montreal, Que., Canada.

Project: DR-20

Object: Report No. 3

Subject: Improvement of Sub-gingival curettage and Gum resection used in the treatment of the Periodontal pockets.

Place: Faculty of Dental Surgery,
University of Montreal,
Montreal, Que., Canada.

Date: February 5th, 1949.

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Improvement of sub-gingival curettage and gum resection used in the treatment of the periodontal pocket.

Grantee: Jules Thébaud

Project No. : DR 20 Amount of Grant:

SUMMARY OF WORK

- I -

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The same investigation, with different tests is now being conducted in the mouth, on teeth involved with pathosis.

- II -

Curettement of the soft tissue at the Periodontal wall - In trying to eliminate the disorganized layers of epithelial cells on the soft side of the periodontal recorded on microphotographs. Other biopsy materials taken from the marginal gum are actually under preparation.

- III -

Curettement of the bottom of the Periodontal pocket - Due to the difficulty in obtaining biopsy materials regarding this part of our investigation task, we have performed a deep curettage with our broach-type curette and the specimen is under decalcifying process since November last.

- IV -

Improved technique for Gum Resection (Gingivectomy).

In order to complete the second part of our project, we have devoted a considerable amount of time to devise an original armamentarium and also to outline and try a new and improved technique for gingivectomy. Complete details with histological comments and the general outline of our

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Improvement of sub-gingival curettage and gum resection used in the treatment of the periodontal pocket.

Grantee: Jules Thebaud

Project No. : DR 20 Amount of Grant:

SUMMARY OF WORK

- I -

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When intensive practice and critical analysis of this part of our project will convert it to a more precise and a more simplified technique, we shall be able to devote most of our time to the first part of our investigation, that is, to attempt to find improved procedures for the subgingival method.

FIRST PART

IMPROVEMENT OF SUB-GINGIVAL CURETTAGE

FIRST PART

IMPROVEMENT OF SUB-GINGIVAL CURETTAGE

PROJECT DR-20 First Part

Since my last report in February 1948, an average of 500 hours was spent in following the assigned investigation.

- 1 -

Curetting of the cemental wall - To replace the two series of specimens which were not suitably prepared by our technician, from November 1947 to May 1948, a third series of 36 teeth has been decalcified and mounted. Therefore tables 1, 2, 3, 4, 5, 6 presented in our first report regarding the experiments made on selected groups of teeth, have no actual value.

Among those 36 slides or specimens, 10 were found incomplete, on account of rupture or lack of continuity of the cemental layer at the gingival third. They were replaced and the 10 new specimens are actually under the decalcifying process.

EXPERIMENTS - In conducting our experiments on the third series of 36 specimens, we have used only extracted teeth selected at random but on which was a certain amount of calculus. We are now carrying on our investigation, on a second group of teeth "in situ" with periodontal pathosis involved.

In contemplating to improve the armamentarium used in the phase of curetting the cemental surface, we have scaled, finished and polished the gingival third of those 36 teeth, in order to study: (a) the effect produced by each instrument when used alone, (b) the combined effect of various instruments used in a conservative manner, during the scaling and the finishing processes, and (c) the possible gouging and exposure of the dentine, and also the liability of removing the cemental layer at the gingival third when the instruments are slightly overused.

Scaling and finishing were performed at the gingival third, on the mesial and distal sides of each tooth.

As different instrumentations were carried out on each side of every tooth, small notches were made, for identification, on the mesial side at the apical third (no. 10 excepted.)

Scaling - Only routine planning was used during the instrumentation, which was performed with McCall's curettes Nos. 13-14-17 and 18, and the ordinary hoes.

Finishing - In the finishing process, we have, again, tried, beside an ordinary file, some new materials, such as fine metal abrasive disks, (Moyer's abrasive), flattened carborandum points and portions of carborandum disks, in order

TYPE OF PROCEDURE	MESIAL	DISTAL	TEETH	SERIAL NUMBER
Scaling	hoe	0	upper bicuspid	19
Scaling	hoe	0	upper molar	35
Scaling	hoe and curette	curette	upper cuspid	8
Scaling-finishing	hoe,curette and file	curette and file		5
Scaling-finishing	hoe,curette and abrasive steel	hoe and curette	upper central	3
Scaling-finishing	hoe,curette and file	hoe and curette	upper cuspid	10
Scaling-finishing	hoe,curette,file and abras.steel	hoe,curette and file	upper central	13
Scaling	curette	0	lower bicuspid	18
Scaling	curette	hoe	lower cuspid	20
Scaling-finishing	curette	file	lower cuspid	22
Scaling-finishing	curette	abrasive steel	lower cuspid	23
Scaling-finishing	curette	carborandum disk	lower bicuspid	25
Scaling-finishing	curette	carborandum point	lower cuspid	24
Scaling-finishing	curette and hoe	curette and file	lower central	28
Scaling-finishing	curette and file	curette	lower bicuspid	9
Scaling-finishing	curette and file	curette	2nd upper molar	34
Scaling-finishing	curette and abrasive steel	curette and file	lower cuspid	29
Scaling-finishing	curette and abrasive steel	curette and file	upper central	26
Scaling-finishing	curette and abrasive steel	curette	lower cuspid	2
Scaling-finishing	curette and carborandum point	curette	upper central	27
Scaling-finishing	curette and carborandum point	carborandum point	lower lateral	16
Scaling-finishing	curette,file and abrasive steel	curette and file	upper lateral	12
Scaling-finishing	curette	curette and hoe	upper central	30
Finishing	file	0	lower bicuspid	4
-finishing	0	File	lower central	32
Finishing-finish.	file	abrasive steel	lower bicuspid	33
Finishing-finish.	file and abrasive steel	file	upper bicuspid	7
Finishing	abrasive steel	0	upper central	1
Finishing	abrasive steel	file	lower cuspid	6
Finishing	0	abrasive steel	lower central	31
Finishing	abrasive steel	0		21
Finishing	carborandum disk	0	lower cuspid	11
Finishing	carborandum disk	abrasive steel	lower bicuspid	17
Finishing	carborandum disk	curette	2nd upper molar	36
Finishing	carborandum point	0	upper lateral	14
Finishing	abrasive steel and file	0		

TABLE A (cont'd)

EXPERIMENTS PERFORMED ON EXTRACTED TEETH

Serial No.	Deposit	Date of decalcifying process	OBSERVATION	
			MESIAL	DISTAL
19	+	June/48	Thinned and detach. at end of ging.	Normal thickness with perid.debris
35	- +	July/48	Thinned(slightly)	Normal thickness
8	++ - ++	May/48	Thinner than distal, regular	Normal thickness
5	++ - +	May/48	Slight.thinned in compar. to distal side	Normal thickness, but detached
3	+ - ++	Jan./49		
10	++ - +	May/48	Very thinned (labial)	Slightly thinned (lingual)
13	+++ - ++	Jan./49		
18	+ - ++	June/48		
20	+ - +++	June/48	Slightly thinned	Detached,missing in few spots
22	++ - ++	June/48	Slightly thinned	Very thin,on 1 isol.spot and missing in some places.
23	++ - ++	June/48	Slightly thinned	Thinned and grooved
25	+ - ++	June/48	Slightly thinned	Very thinned,almost absent
24	+++ - +	June/48	Thickness almost normal	Grooved in separate spots
28	+ - +	June/48		
9	+ - ++	Jan./49		
34	+ - +	July/48	Slightly thinned	Almost normal
29	+++ - +	June/48	Thinned and irregular	Normal,reg.but very thinned at the enamo-cemental junction.
26	++ - +	Jan./49		
2	+ - +	June/48	Very thinned on separate spots	Thinned but regular
27	++ - +	Jan./49		
16	++ - ++	June/48	Thinned and slightly irregular	Slightly thinned
12	++ - +	July/48	Regular, almost normal in thickness	Very thinned,and missing in var. spots
30	+ - +	Jan./49		
4	+ - +	July/48	Normal with few adhesions of debris	Very thinned, almost reg.but missing at the enamo-cemental junction
32	+ - +	Jan./49		
33	++ - +	Jan./49		
7	++ - +	May/48	Slightly thinned	Normal thick.and perid.fibres
1	+ - +	May/48	Normal thickness but slight.irreg.and groov.	Slightly thinned but almost absent at the gingival

TABLE A (cont'd)

EXPERIMENTS PERFORMED ON EXTRACTED TEETH

Serial No.	Depositi	Date of deoalcifying	OBSERVATION	
			PROCESS	DISTAL
19	+	June/42	Thinned and detach. at end of prep.	Normal thickness with perid.membr
35	- +	July/42	Thinned(slightly)	Normal thickness
8	++ - ++	May/42	Thinner than dicoal, regular	Normal thickness
5	++ - +	May/42	Slight.thinned in cooper. to dicoal side	Normal thickness, but decreased
3	+ - ++	Jan./43		
10	++ - +	May/42	Very thinned (labial)	Slightly thinned (lingual)
13	+++ - ++	Jan./43		
18	+ - ++	June/42		
20	+ - +++	June/42	Slightly thinned	Decreased,missing in few spots
22	++ - ++	June/42	Slightly thinned	Very thin,op i isol.spot and missing in some places.
27	++ - ++	June/42	Slightly thinned	Thinned and grooved
25	+ - ++	June/42	Slightly thinned	Very thinned,almost absent
24	+++ - +	June/42	Thickness almost normal	Grooved in several spots
28	+ - +	June/42		
3	+ - ++	Jan./43		
34	+ - +	July/42	Slightly thinned	Almost normal
29	+++ - +	June/42	Thinned and irregular	Normal,reg.but very thinned at the enamo-cemental junction.
26	++ - +	Jan./43		
2	+ - +	June/42	Very thinned on separate spots	Thinned but regular
37	++ - +	Jan./43		
15	++ - ++	June/42	Thinned and slightly irregular	Slightly thinned
12	++ - +	July/42	Regular, almost normal in thickness	Very thinned,and missing in var. spots
33	+ - +	Jan./43		
11	+ - +	July/42	Normal with few adhesions of dentin	Very thinned, almost reg.but missing at the enamo-cemental junction
36	+ - +	Jan./43		
39	++ - +	Jan./43		
7	++ - +	May/42	Slightly thinned	Normal thick.and perid.fibres
1	+ - +	May/42	Normal thickness but slight.irreg.and groov.	Slightly thinned at the singular almost absent

TABLE A (cont'd)

EXPERIMENTS PERFORMED ON EXTRACTED TEETH

Serial No.	Deposit	Date of decalcifying process	OBSERVATION	
			MESIAL	DISTAL
6	≠ - ≠	July/48	Normal thickness with adhesions of debris	Slightly grooved
31	≠ -	May/48	Irregular and grooved	Normal with adhesions
21		June/48	Thinned and very irregular	Normal
11	- ≠	Jan./49		
17	≠ - ≠	July/48	Very thinned	Almost normal
36	≠ - ≠	June/48	Thinner than distal, slight. irreg.	Normal with periodontal adhesions
14	≠ - ≠	June/48	Thinned and slightly ondulated Roughened and slightly grooved	Slightly thinned

TABLE A (cont'd)

EXPERIMENTS PERFORMED ON EXTRACTED TEETH

Serial No.	Deposit	Date of descalcifying process	OBSERVATION MESIAL	DISTAL
6	+ - +	July/48	Normal thickness with adhesions of debris	Slightly grooved
31	+ -	May/48	Irregular and grooved	Normal with adhesions
21		June/48	Thinned and very irregular	Normal
12	- +	Jan./49		
17	+ - +	July/48	Very thinned	Almost normal
30	+ - +	June/48	Thinner than distal, slight. irreg.	Normal with perlodontal adhesions
14	+ - +	June/48	Thinned and slightly undulated Roughened and slightly grooved	Slightly thinned

to record some observations during the microscopic study of the specimens. Those observations are listed in Table (A).

General considerations on macroscopic studies - Our remarks regarding the macroscopic study during the various phases of instrumentation, repeated during the preparation of the three series, are the same as presented in our first report of February 1948.

In carrying out the same experiments on live specimens in the mouth, we are attempting to conduct, on the same teeth, some other tests regarding the sensibility to: a) tactile contact, and b) to change of temperature after instrumentation.

Interpretation of the findings - We are unable, up to now, to determine in what measure the cemental surface is liable to be gouged during an excessive scaling procedure because our study has been limited to a few materials, but we have noticed that during this scaling, even with the curette alone, we create a slight thinning of the cemental layer. Thinning is much more pronounced when the hoe is used, with or without the curette,

especially on the lower anterior teeth where the cemental layer is so thin, but sharp curettes and hoes may cut through into the non-tubular dentine when (figures 2 and 3) instrumentation is repeated three or four times. Further study will be made on this respect.

A few slides were discarded on account of the absence or lack of continuity of the cement. We are not in a position, as yet, to say if this is accidental, due to technical error, because a 4% formol batch was used instead of one of 10%, or if the cemental substance was entirely worn out in some cases, during the scaling.

When the other 10 specimens will be mounted, we may have an opinion regarding a conclusion on this matter. Nevertheless, it seems that a great amount of material is necessary before any definite opinion can be expressed.

When we compare any side of one root treated with any instrument (hoe, curette, file, etc.) with the other part of the root untouched, we notice already some difference: the untouched side bears some adhesions of the cemental cuticula and calculus debris (figure 1), while the scaled side is thinner, and missing in spots.

When the finishing procedure is added to the scaling, even with the file, the wearing is more marked, and the surface of the cement layer is not so regular as one may think, as small eminences can be detected under the microscope (figures 4 and 5). It seems that if the filing

Fig. 1 - Untreated cemental layer with peridental adhesions and debris and showing its normal thickness.

1

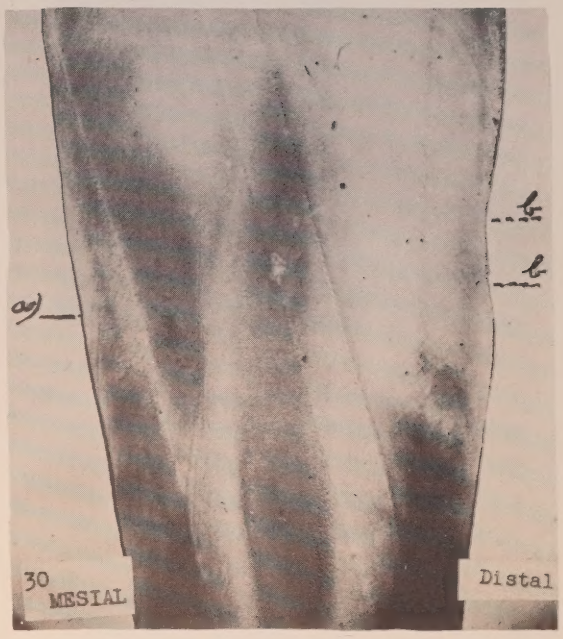

Fig. 2 - a) Mesial site of a root treated with a curette
b) Distal site of a root treated with curette and hoe.

2

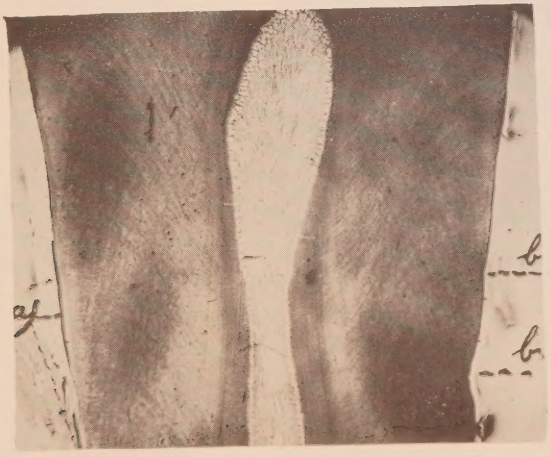

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Fig. 3 - Root of an upper bicuspid
a) Normal thickness of cement with adhesions of debris.
DISTAL
MESIAL
b) Reduced and grooved cemental layer.

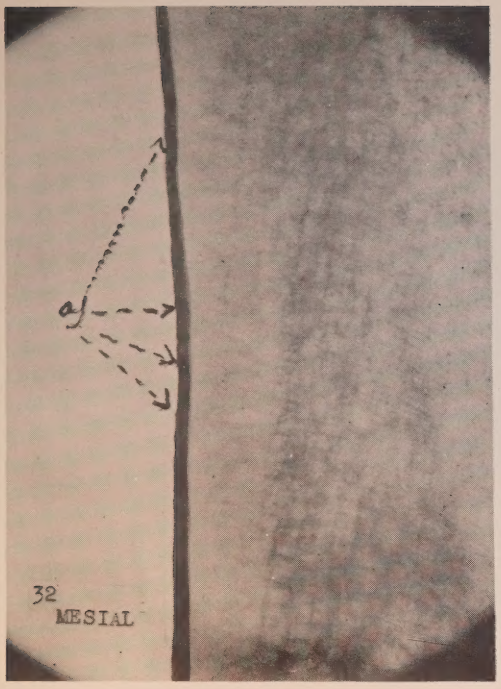

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Fig. 4 - Treated mesial side of a root with a file
a) small eminences

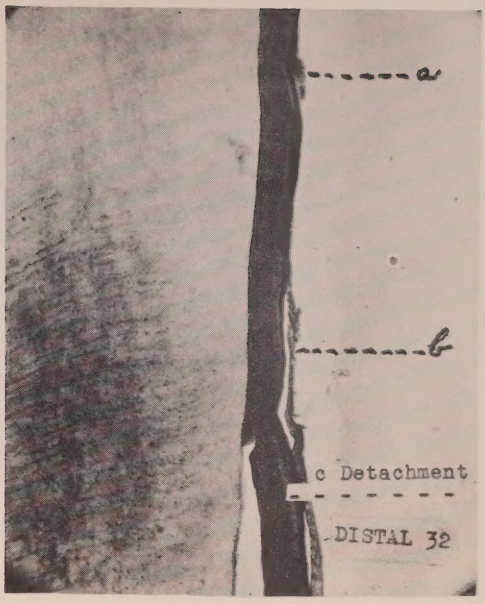

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Fig. 5 - Untreated distal part of a root showing normal thickness of the
a) debris
b) cement cuticula
c) detached cemental layer

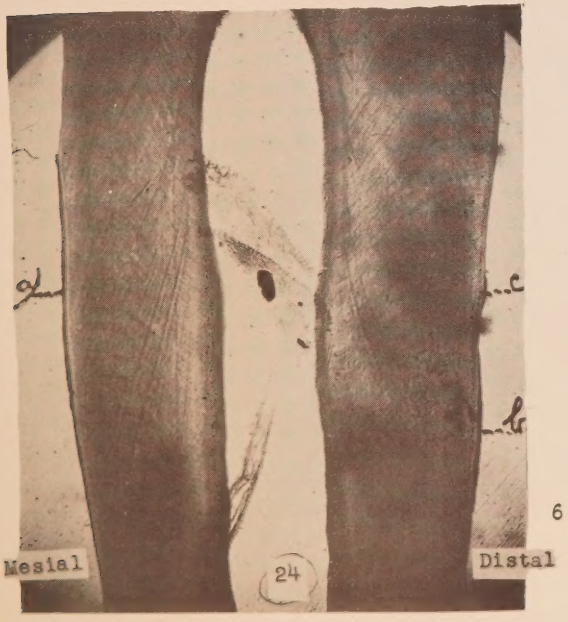

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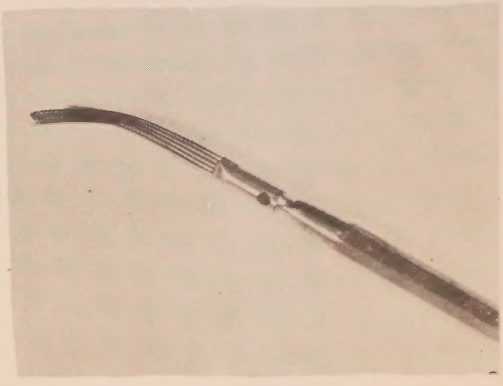
Fig. 6 - Lower cuspid scaled on mesial side with a curette and scaled and finished on distal part with a carborandum point.



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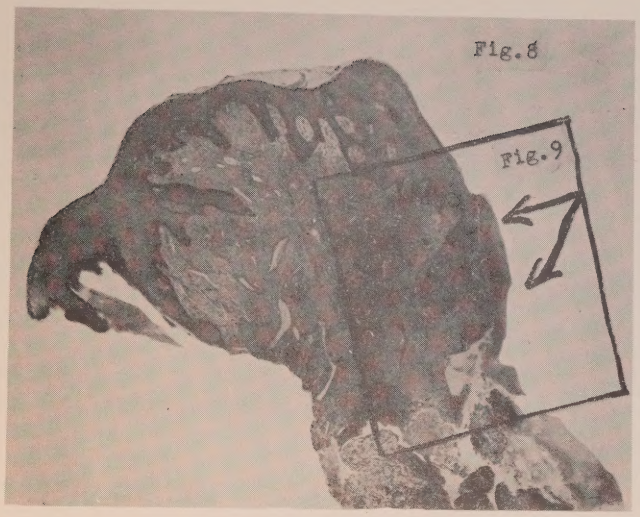


Figs.8,9 Part of a pocket wall, near the base showing curetted epithelium and connective tissue.

is slightly overdone, the dentined substance becomes readily exposed (Table A).

In trying to obtain a smoother surface with other materials applied with finger pressure, such as carborandum point or disk, we notice that those abrasive materials scale and finish the cemental surface at the same time (figure 6). But no statement can be made as yet regarding their efficiency and liability to expose the non-cellular zone of dentine.

II

Curettement of the soft tissue at the Periodontal wall - To find a radical procedure of eliminating the disorganized layers of epithelial cells and the underlying connective tissue at the inner wall of the soft side of the periodontal pocket, we have devised a fine scraper, made with coarse broaches. With the help of the S.S. White Company, in Philadelphia, we have prepared a sample of this instrument, (figure 7) which we have tried clinically on ten (10) patients, to remove the epithelial layer and expose the subjacent mucus membrane at the marginal region of the gum. The positive result is that, after a few scraping movements, the surface of the gum became raw, with profuse bleeding, and apparently devoid of its protecting epithelial covering.

We have further conducted our experiments on the inner wall of the pocket on 3 specimens which were biopsy materials. But the scrapping or curetting was made too close to the bottom of the pockets - as shown in figures 8 and 9.

Other tests will be performed at higher points of pockets wall with McCall's solution and without it, in order to find a more radical method of removing the epithelial cells.

III

Curettement of the base of the periodontal pocket - Having in mind the great disproportion between the thickness of the periodontal membrane at the base of the pocket and the size of the ordinary curette used for the purpose of cleaning that very small region, we have performed a few curettages with our broach-type curette, conducting thus, some clinical experiments.

One specimen is actually under decalcifying process; we are looking forward to carry on our investigations, further, as soon as suitable biopsy cases will be available at the Department of Surgery.

SECOND PART

IMPROVED TECHNIQUE IN GUM RESECTION (GINGIVECTOMY)

SECOND PART

IMPROVED TECHNIQUE IN GUM RESECTION (GINGIVECTOMY)

PROJECT DR-20 SECOND PART

Improved technique in gum resection (Gingivectomy)

Many authors recommend, after superficial probing of the pockets, that continuous and horizontal incisions be made at the level of the pockets depths which are indicated by interproximal incisions made with sawlike curettes. Others recommend continuous and undulating incisions after the measurement of the pockets depths with a pair of markers and in most techniques, the curetting of the alveolar bone is strongly recommended, and others give no special attention to the removal of tissue debris that are left in the interproximal spaces. (Figures A, B, C, D).

In order to avoid sacrifying too much normal tissue, thus respecting the integrity of some groups of the fibres of the periodontal membrane and the substance of the alveolar bone, which, most of the time, is not necrotic, we condemn horizontal incisions and the use of bone curette. We have devoted most of our time on this part of the project in designing and outlining a more adequate armamentarium for precise measurements of the periodontal pockets and for the dissecting and the removing of the pathological tissue.

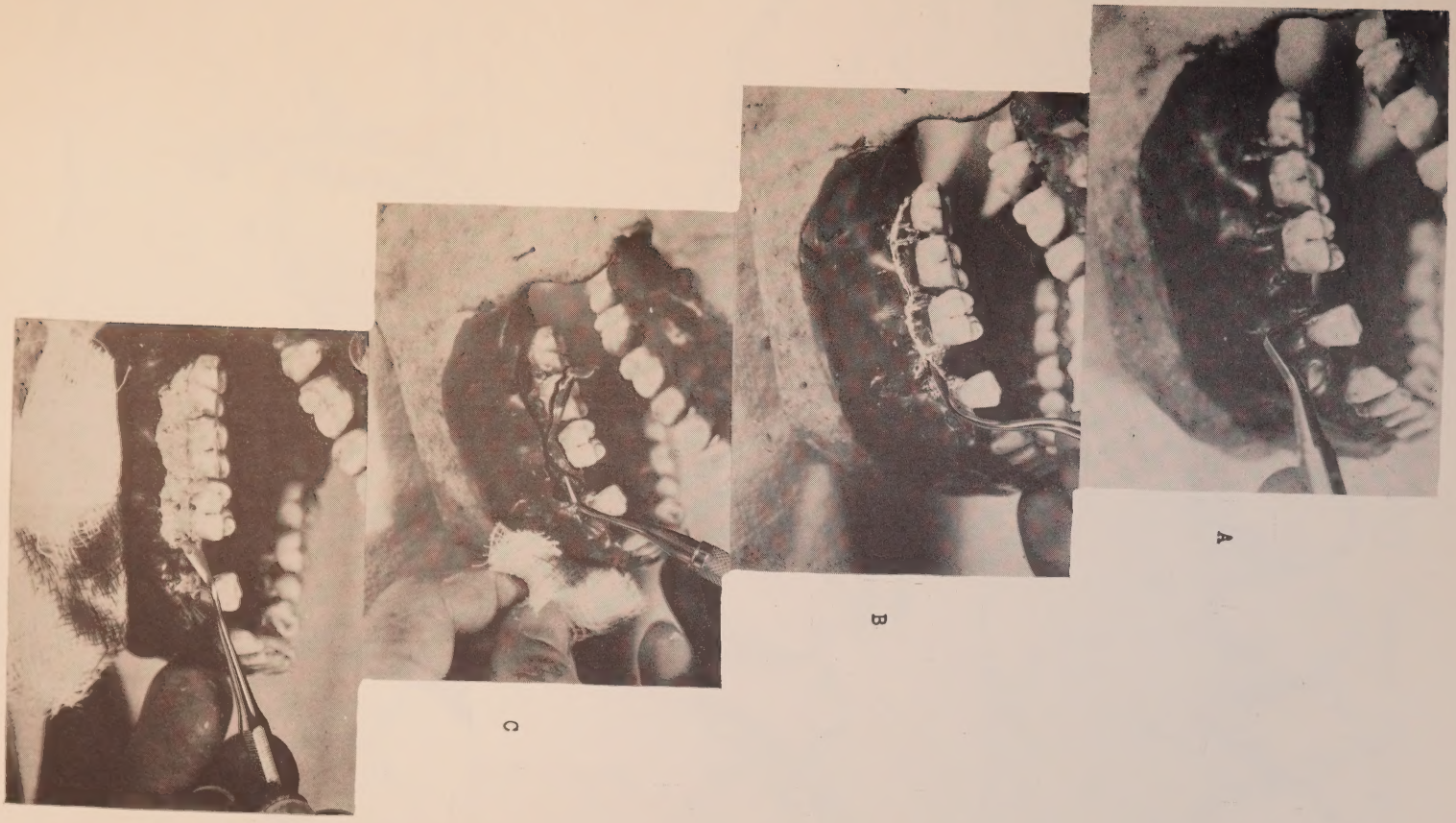
Since gingivectomy is often performed when the subgingival curettage has proven unsatisfactory or when deep pockets are developed, we notice, even in the advanced cases, that the incisions have not to be made neither in a continuous nor in a horizontal plan.

In most cases, when accurate, precise measurement of the pockets is made, rarely is it found that the depths are equal at the mesial and at the distal sides of teeth seriously involved with periodontal lesions (Fig. 10).

If we consider two (2) millimeters as a limit depth for the normal sulcus, we find that the position of such a point, or boundary zone changes greatly in each case, as no clear-cut difference can be established between normal and pathological tissues on the basis of this criterium (?)

In marking first, or in settling the limits of a pocket, bucally or lingually, at its greater depth and, secondly at its lesser depth of 2 mm., we eventually outline an inverted cone shape area, containing the pathological tissues which mass of tissue includes, more or less, the bulk of the pathological papillae (Fig. 10).

In our plea for adequate differentiation between the normal and the pathological region of the gum by precise measurement, we suggest that gum resection in which the papillae, most of the time, is the main part of the pathological area, be designated "papillectomy", instead of gingivectomy.



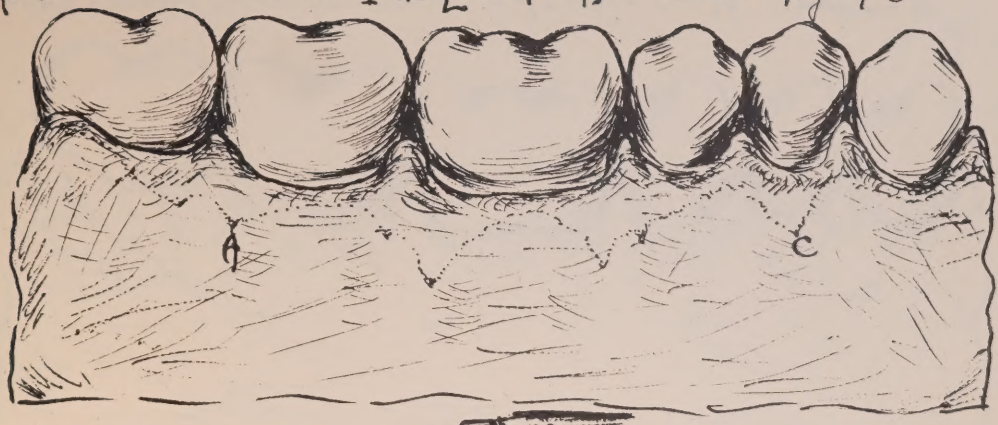
Figs.A,B,C,D - One of the well known methods for gum resection

A C > Pockets

Papillectomy

Fig-10

1-



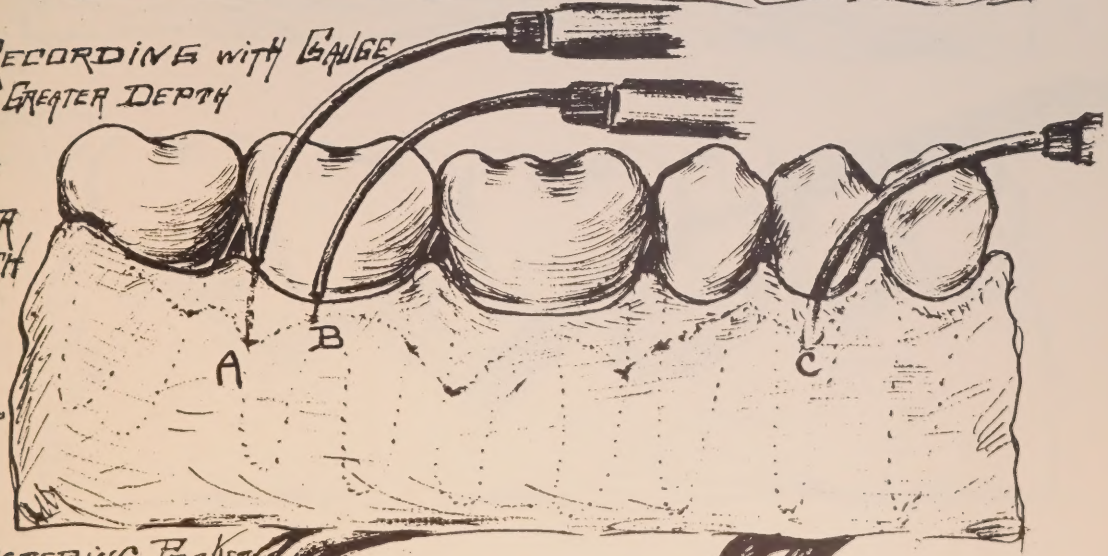
Recording with Gauge

(A C) Greater Depth

&

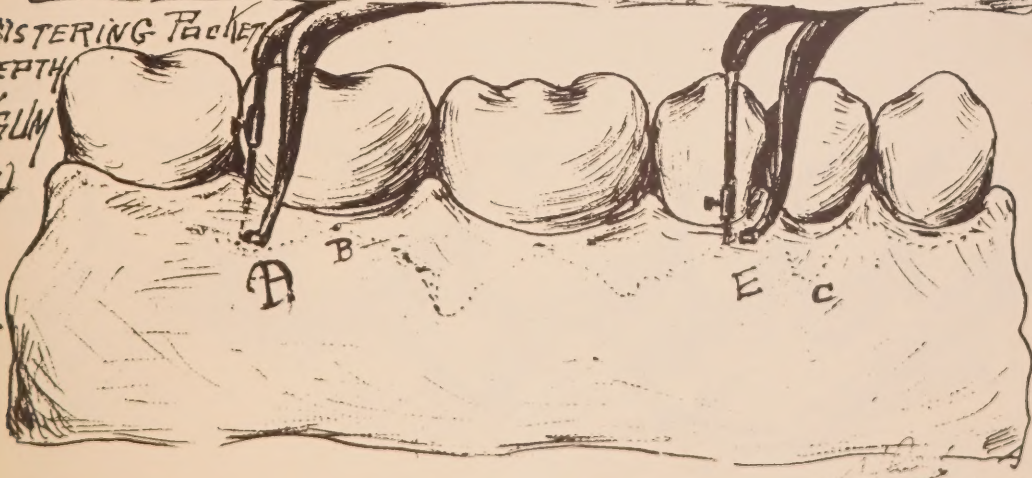
Lesser Depth (B)

2-



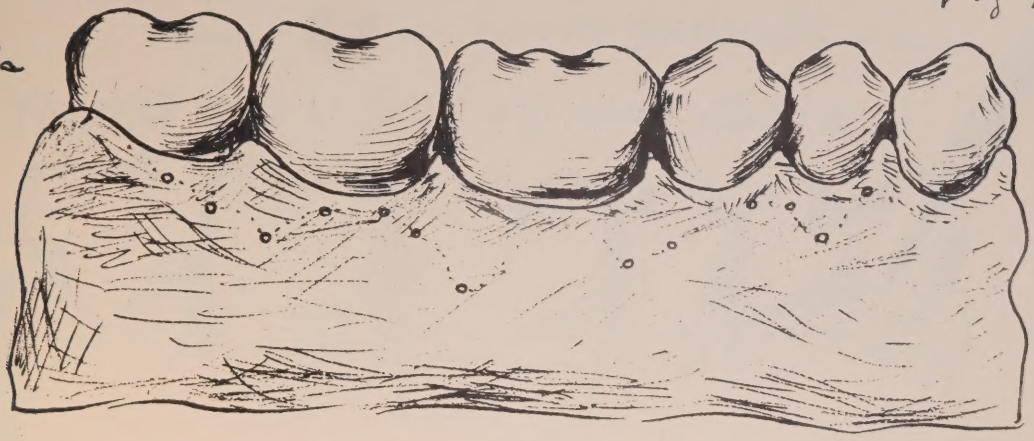
Registering Pocket Depth on the Gum (A E)

3-



Registered Pocket Depths. — "Papillectomy" — Fig 10

4.

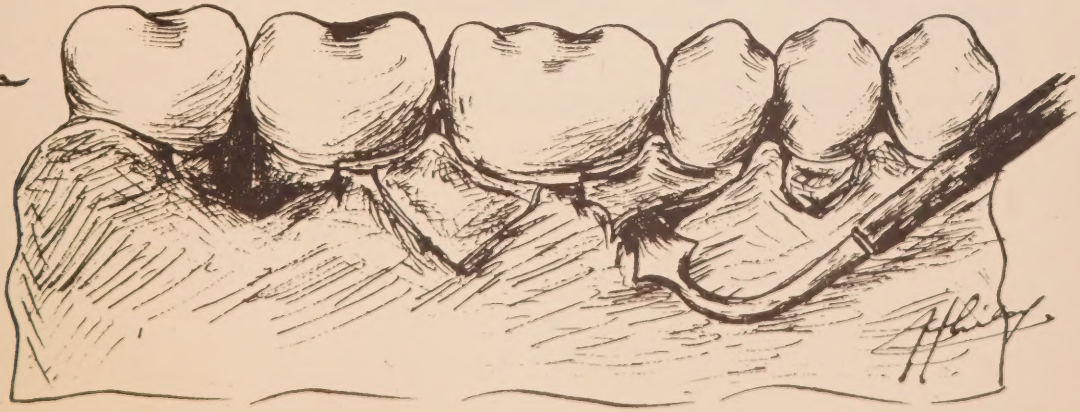


Resecting the Gum

5.

Lifting the Resected Papillae

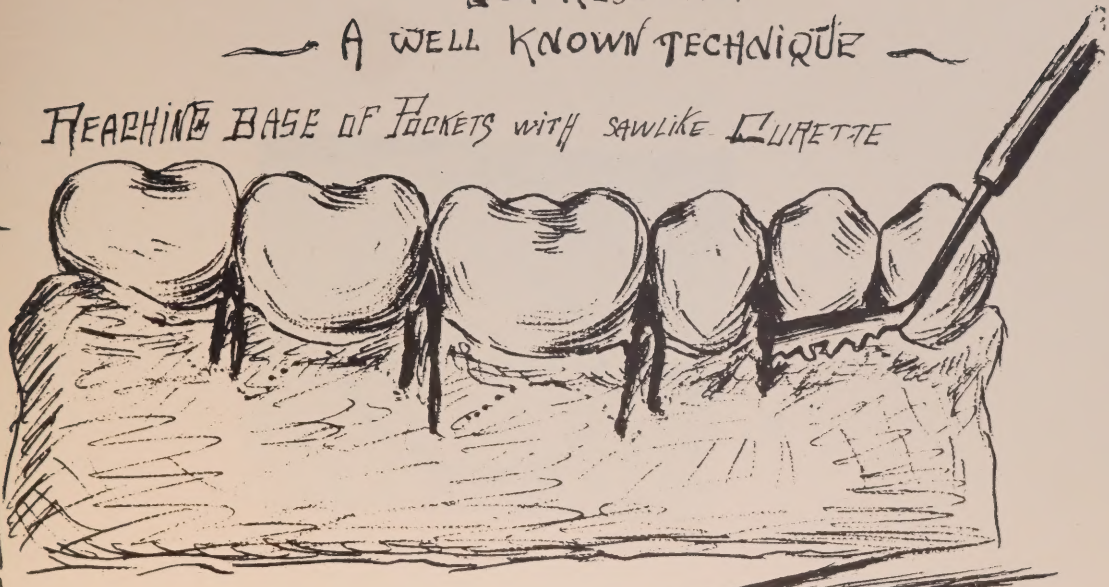
6.

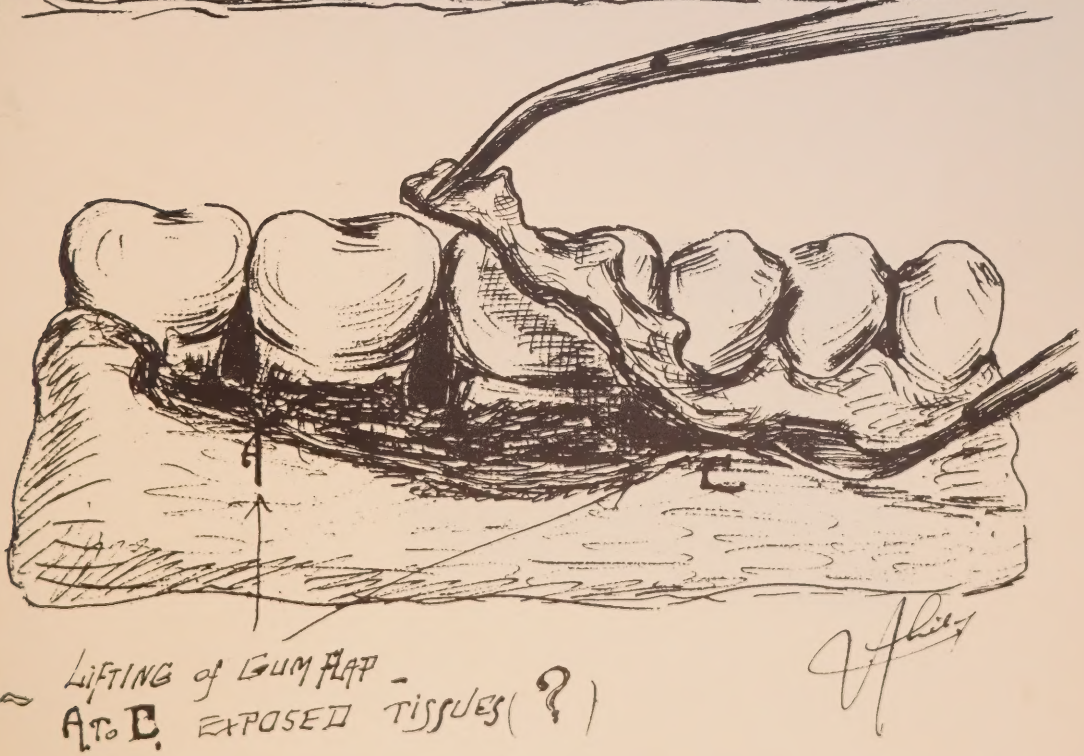


GUM RESECTION

— A WELL KNOWN TECHNIQUE —

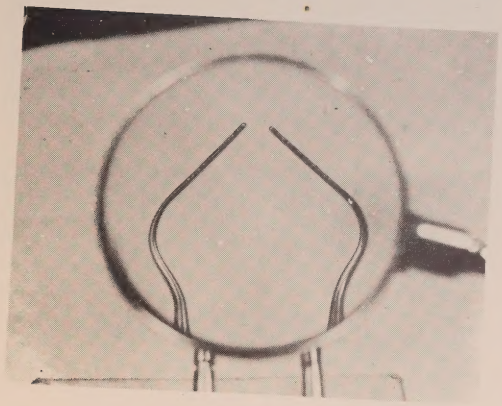
7 — HEARHING BASE OF POCKETS WITH SAWLIKE CURETTE





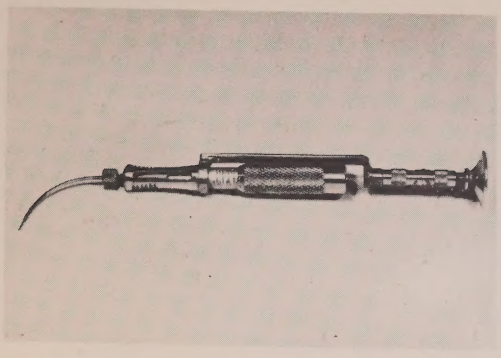
8 — LIFTING of GUM FLAP - A to B. EXPOSED TISSUES (?)

Fig-10



II

II'



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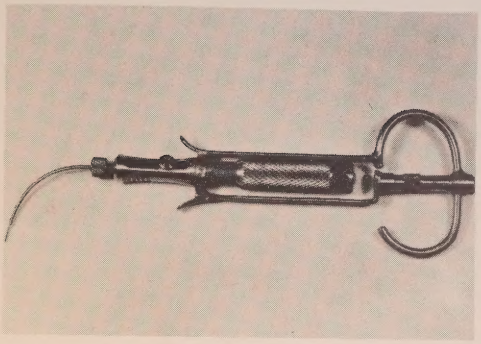

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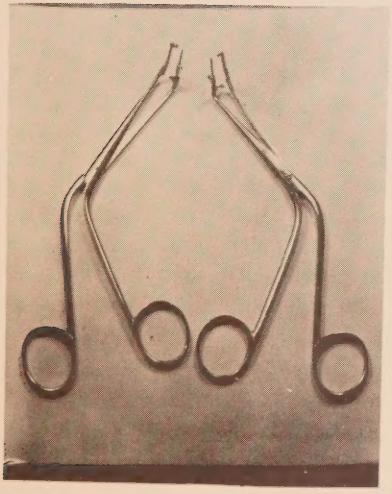

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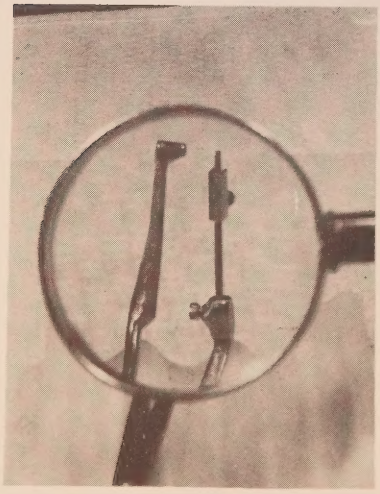

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(Second Part - cont'd)

New armamentarium for "papillectomy" or gingivectomy used in the treatment of the periodontal pockets -

1. Probes - In the preliminary probing to the charting of any case, we recommend a pair of calibrated and curved probes, right and left, which can be accurately inserted in the pockets, parallel to the long axis of the teeth when probing at the interproximal spaces. (Fig. 11).

2. Periodontal Gauge - In charting and recording the exact depths of the pockets we design and use, instead of the probe, which we do not find sufficient enough for that purpose, a special gauge, calibrated in millimeters.

When the calibrated wire is pushed out and introduced in a pocket by turning the barrel of the instrument, the depth is readily registered on the gauge, in any position, on the upper and on the lower jaws. (Figures 12 and 13).

This new instrument with sterilized and interchangeable parts has proven to be very efficient in our periodontia practice. We hope to improve it in the future.

3. Calibrated pocket markers - The current pocket markers in use are not quite efficient, since they are not calibrated and their points are too large and too blunt making it difficult to reach the bottom of the pockets.

We therefore recommend, a pair of pocket markers in which one end is calibrated in millimeters and has a mobile barrel adjustable at any point. By means of a fine calibrated end, (Fig. 14) the base of the pockets is easily reached and duplication of measurements previously obtained can be carried out with dental gauge. The depths are then marked on the gum with the other end of the marker which has a tubular form. With the screwed barrel, the calibrated point may be set at a "conventional" depth of 2 mm., considered as a limit between the normal sulcus and the beginning of the pocket. The tubular end of the marker registers on slight pressure the various depths on the gum, without cutting into it. For better indication of the marked points, the small tube at the end can be filled with a dye, such as the methylene blue or the gentian violet. This instrument will be improved.

4. Special knives - In order to make the incisions more adequately in the posterior regions, we make use of a pair of knives, right and left (figure 15). For the anterior region, we recommend a razor-shaped knife, No. 3. Their curved shapes are quite suitable to the obliqued and inclined directions given to those incisions.

(Second Part - cont'd)

New armamentarium for "papilleotomy" or sphincterotomy used in the treatment of the periodontal pockets -

1. Probes - In the preliminary probing to the charting of any case, we recommend a pair of calibrated and curved probes, right and left, which can be accurately inserted in the pockets, parallel to the long axis of the teeth when probing at the interproximal spaces. (Fig. 11).

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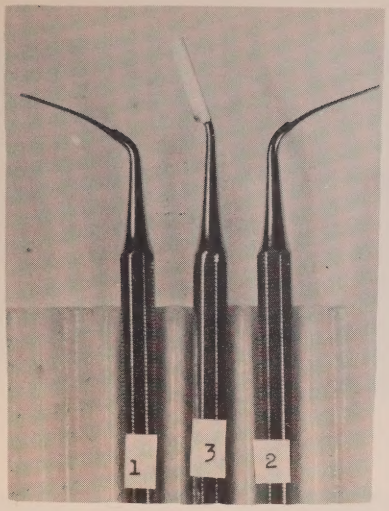
4. Special knives - In order to make the incisions more adequately in the posterior regions, we make use of 1 pair of knives, right and left (figure 15). For the anterior region, we recommend a razor-shaped knife, No. 3. Their curved shapes are quite suitable to the obliqued and inclined directions given to those incisions.



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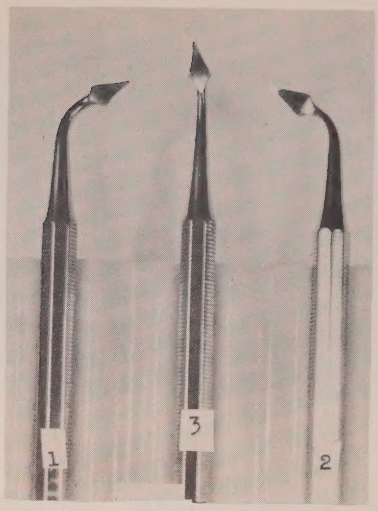

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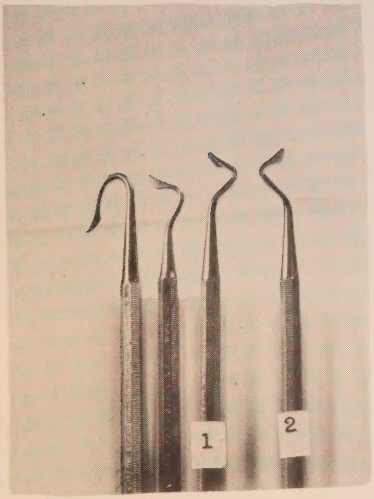

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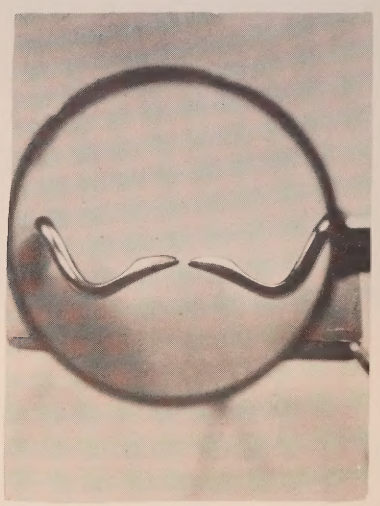

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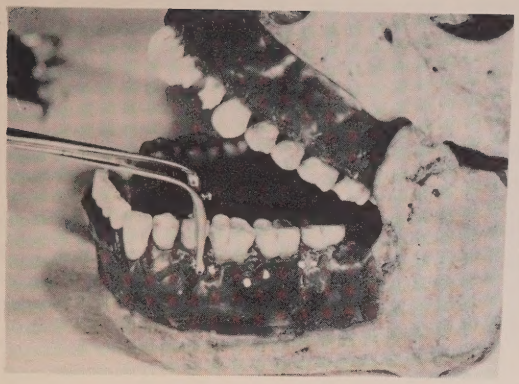

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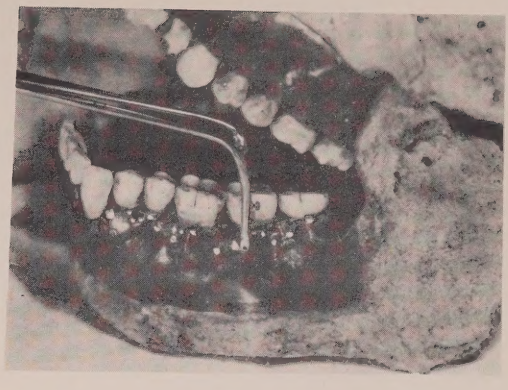

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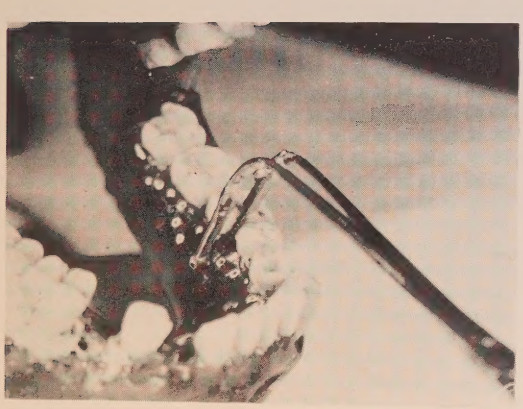

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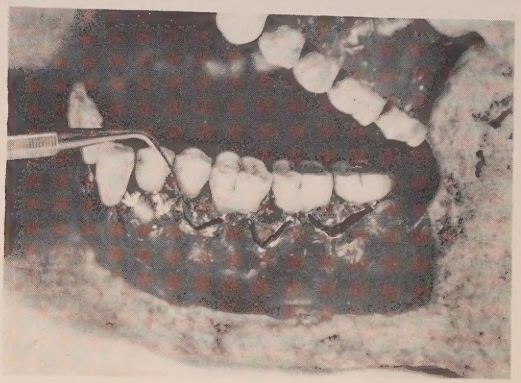

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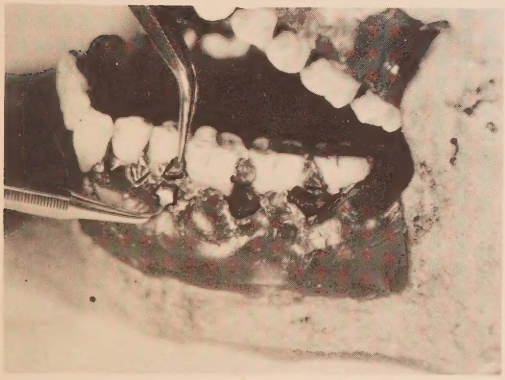

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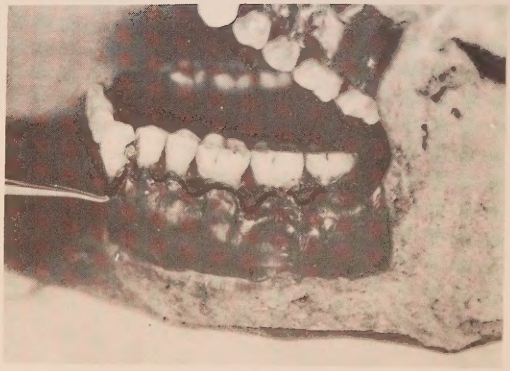


24

OUR METHOD

5. Dissectors for papillae (papillo-levers) - For the dissection and the detachment of the resected part of the gum, a pair of triangular dissectors is used (Nos.1 and 2) right and left, for the posterior part.

A third one, (No. 3) is used for the anterior region (figure 16).

6. Tissue pushers - After the removal of the dissected part of the gum the curettage of the pathological tissues is completed by means of special instruments, with which the tissue debris can be pushed out at the interproximal spaces (figure 17).

- OPERATIVE TECHNIQUE -

After routine probing, the complete removal of calculi and the equilibration of the articulation, the exact depths of the pockets are registered by means of our special gauge allowing an accurate charting of the case (figure 18). We, then, proceed, for instance, in the following manner for the lower posterior right region:

1o - Marking of the pocket depths - With the pocket marker all the "greater depths" are indicated on the gum at the interproximal spaces, mesially and distally, for each tooth (figure 19). As a second movement, the screwed barrel is lowered to a blocked point of the calibrated probe, at 2 mm. (figure 10). That point is then introduced in the interproximal space, under the gum, at the mesial side of the last tooth (figure 10). We then run the exposed point of the instrument along the buccal part of the tooth, until it is settled at the "conventional" depth of 22 mm. That depth is recorded on pressing the tubular point against the gum. The same operation is repeated on running the barrel of the probe over the edge of the gum, on a mesial direction buccally on the next tooth, until another "conventional point" of 2 mm. is met (figure 20).

When this part of the marking is done for the buccal side of the teeth, it is repeated for the lingual side (Fig. 21).

2o - Incisions - With the various points registered on the gum, we then follow indicated spots by making the incisions with our special knives, right or left, according to the side of the mouth treated, buccal or lingual. Inverted cone shaped incisions are mostly obtained following this part of the operation (figure 22).

3. Dissectors for papillae (papillo-lavers) - For the dissection and the debridement of the resected part of the gum, a pair of triangular dissectors is used (Nos.1 and 2) right and left, for the posterior part.

A third one, (No. 3) is used for the anterior region (figure 16).

4. Tissue pushers - After the removal of the diseased part of the gum the courettage of the pathological tissues is completed by means of special instruments, with which the tissue debris can be pushed out at the interproximal spaces (figure 17).

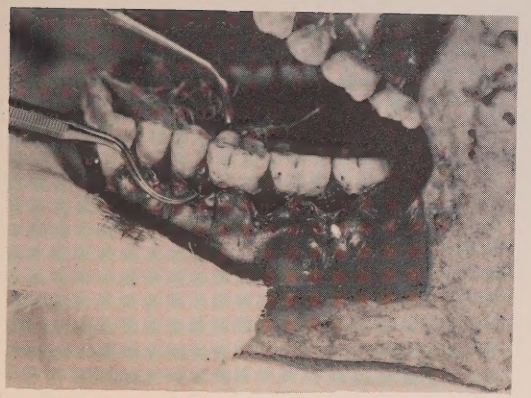
- OPERATIVE TECHNIQUE -

After routine probing, the possible removal of calculi and the equilibration of the articulation, the exact depths of the pockets are registered by means of our special gauge allowing an accurate charting of the case (figure 18). We, then, proceed, for instance, in the following manner for the lower posterior right region:

1o - Marking of the pocket depths - With the pocket marker all the "greater depths" are indicated on the gum at the interproximal spaces, mesially and distally, for each tooth (figure 19). As a second movement, the screwed barrel is lowered to a blocked point of the calibrated probe, at 2 mm. (figure 1o). That point is then introduced in the interproximal space, under the gum, at the mesial side of the last tooth (figure 1o). We then run the exposed point of the instrument along the buccal part of the tooth, until it is settled at the "convexities" depth of 22 mm. That depth is recorded on pressing the tubular point against the gum. The same operation is repeated on running the barrel of the probe over the edge of the gum, on a mesial direction buccally on the next tooth, until another "convexities point" of 2 mm. is met (figure 2o).

When this part of the marking is done for the buccal side of the teeth, it is repeated for the lingual side (fig. 21).

2o - Incisions - With the various points registered on the gum, we then follow indicated spots by marking the incisions with our special knives, right or left, according to the side of the mouth treated, buccal or lingual. Inverted cone shaped incisions are mostly obtained following this part of the operation (figure 22).



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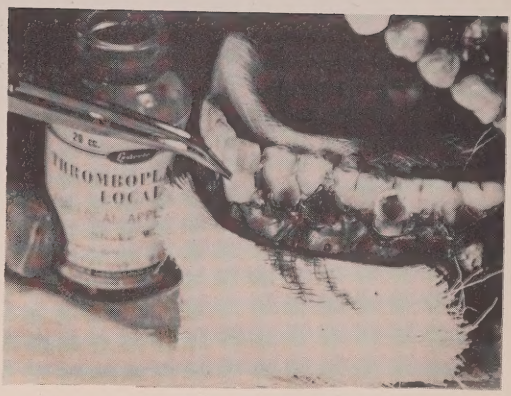

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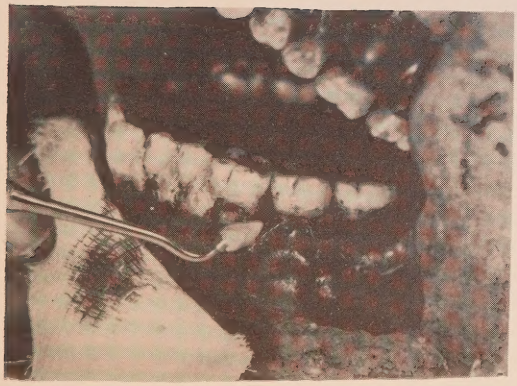

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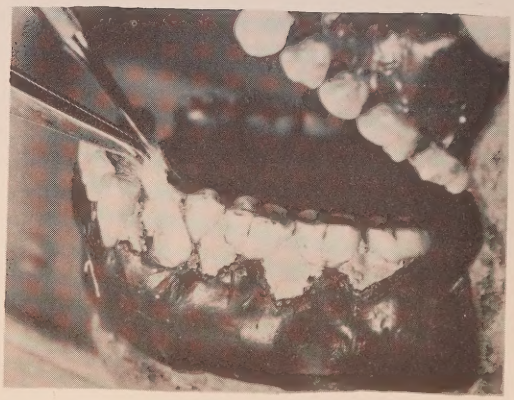


28

3o - Dissecting and removing of the papillae - Soon after that, the incisions are made, the dissectors (figure 23) are introduced under the resected part of the soft tissue with a slight "forward and backward" movement in the interproximal space, having in mind a dissecting on rather than cutting in the soft tissue. The complete removal of the resected gum may be completed by using of fine Towner's gum knives (figure 24).

4o - Curettement and Removal of tissue debris - The fibrous adhesions of granulomatous appearance can be removed with the curette. But, to prevent curetting in a free space between the teeth in removing fine particles of tissue (Fig.25), a small piece of gauze or cotton is introduced lingually at the interproximal space, then it is pushed and maintained by means of the tissue pushers. This instrument makes it easy to detect and reach all tissue debris by exposing them on the buccal opening of the interproximal area.

5o - Packing - Following the curetting of the pockets, an hemostatic is applied between all the teeth with fine pellets of cotton (figure 26). They are removed after five minutes and then we start on the lingual side to set the packs which are deposited in small cone-shaped masses, separately in each interproximal space (figure 27). Great care being taken to avoid pressure in soft tissue with the packs. Preferably they should be pressed and squeezed against the crown of the teeth (figure 28).

The same operation is then repeated on the buccal side and the union of cones is facilitated by pressing them from both sides with the finger-tips or a pellet of cotton.

Conclusion - In accordance with the statements recently formulated by Gottlieb and Orban who do not recommend the curettement of the alveolar bone, because they do not believe that it is a potential focus of necrosis, we have devoted most of our attention in approaching the matter by indicating accurate means for the detection and resection of the pathological parts of the gum.

Our object has been therefore to respect the integrity of every element of the peridental membrane which is liable to be affected when too radical methods are employed.

In looking for a greater depth of a pocket, it is obvious that one should not expect to localize it always at the interproximal region of every tooth, because it happens that the greater depth might be situated about the middle of a tooth, under the gingival (Fig.10^{c}) festoon, on the labial or on the lingual side: while the lesser depth or the END of the pocket might be located near a papilla. (Figs.10^{e,b}).

Even in such a case, which might be considered as an exception, the outline of such a pocket has more or less an inverted cone-shape; for no pockets are situated on rigid horizontal plan. Two shallow pockets might be continuous, join or end at the same point, but most of the time their greater depths can easily be differentiated from their lesser depth.

However, we recommend to detect the limit between normal and pathological tissues, in order to avoid loss of vital elements or too much "extention for prevention".

In résumé, this conservative surgery is based on the following steps:

1o - Localize the pockets with probes at routine examination.

2o - Record, by means of a gauge, where the pockets progress (greater depth) and where they end (lesser depth).

3o - Register the limits and the outline of the pockets by means of markers.

Although we consider that this method is in harmony with the law of esthetics, we do not recommend it, as a rule, for the anterior part of the mouth, because we believe it is better to use, for that particular region a more conservative method, the sub-gingival curettage or the semi-flap technique when the pockets are deep.

We hope that with further practice and with constructive criticism, this technique of gum resection or "papillectomy" may be improved.

Jules Thébaud,
270 Outremont Avenue,
Montreal, P.Q.

COPY

THE S.S.WHITE DENTAL MANUFACTURING CO.

December 16, 1948.

Dr. Jules Thébaud,
270 Ave. Outremont,
Montreal, Canada.

Dear Doctor Thébaud:

We are pleased to inform you that we have received advice from our Factory concerning the four Special Long Handle Tissue Pushers and two Needle Holders you left with us as samples at the time of your last visit to our Philadelphia Headquarters on the third of this month.

The Factory informs us that they can supply all of these instruments within 120 days after receipt of a definite order for them, and that the price will be as follows:

Tissue Pushers, Nos. 1,2,3,4, Tarno..... $2.75 each
Needle Holders, Tarno ..... $5.25 each

They, however, raised the question as to the correct width of the space between the two sides of each Needle Holder, because No.1 measures .027" wide at the center and .013" at the point. Needle Holder No. 2 measures .015" at the center and .020" at the point.

The Factory is of the opinion that the sides of the slot should be parallel, and suggest an intermediate width of.018".

Will you please inform us if this is in accordance with your desires and if we should instruct the Factory to proceed with the manufacture of these Instruments.

It is our understanding that you want one each of all six of these instruments made up on special order. Is this correct ?

Awaiting with interest your further word in the matter, we are,

Yours very truly,

THE S.S.WHITE DENTAL MFG.CO.

P.M. Barber
Ass't Export Manager.

PMB:LC

COPY

THE S.S. WHITE DENTAL MANUFACTURING CO.

December 28, 1948.

Dr. Jules Thébaud,
270 Ave Outremont,
Montreal, Que.

Dear Dr. Thébaud:

We are enclosing a sample of the joined-together Barbed Broaches mounted in a Cone Socket Attachment suitable for use in a Cone Socket Handle similar to the samples and the drawing of such an instrument that you left with us at the time of your last visit to our Philadelphia Headquarters.

The Barbed Broaches that we have mounted in the Cone Socket Attachment are not as coarse as the samples that you left with us, but they are the coarsest that we manufacture, and we hope that the special Instruments we have made will serve your purpose.

We are not in a position to quote you prices for any of this special design Instrument without first knowing the quantities in which you would want them manufactured; but, in any event, they would be comparatively costly because we have no manufacturing tools with which to make them and every Instrument we would make for you would have to be a separate hand job, the cost of which would be based largely upon the amount of labour plus whatever raw materials were used in their manufacture.

The samples that you left with us are being returned in this letter, along with the sample of our own manufactured Instrument.

Awaiting with interest your further word in this matter, we are,

Yours very truly,

THE S.S. WHITE DENTAL MFG. CO.

P.M. Barber,
Ass't Export Manager.

PMB:LC

COPY

January 18th, 1949.

Mr. H. Torunsky,
Biology Department,
McGill University,
MONTREAL, Que.

Dear Mr. Torunsky:

After a careful examination of the slides stained and mounted last December, I find that some of them are correct (nos. 5-8-11-15-19-21-24-30-31), a few others are passable, i.e., nos 1-6-10-14-20-22-23-25-27, on account of the cemental layer not being in continuity. But the cemental substance is entirely missing at the gingival 1/3 on one or on both sides of the following slides: 2-3-4-7-9-13-16-17-29-33.

In order to complete my studies, I am preparing 10 specimens to replace the ones which are useless.

They will soon be delivered at your laboratory for adequate preparation.

Very truly yours,

Dr. J. Thébaud.

JT/epr

COPY

APPENDIX "G"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: An investigation of the mechanism of repair of the supporting structure of the teeth.

Grantee: C.H. Best. (The work is done by Dr. W.J. Linghorne.)

Project No.: D.R. 22 Amount of Grant: $ 2200.00

SUMMARY OF WORK

In the report to the last meeting of the Associate Committee the proposed work on this project was outlined under six headings. It was decided to concentrate first on Phases 1 & 2.

Phase 1

Purpose: To study the reattachment of the soft tissues to the tooth following surgical detachment of the soft tissues and the removal of a section of alveolar bone.

The procedure in this study is reported in detail in the full report.

Eighteen dogs were used in this investigation so as to allow specimens at the following stages of healing: 24 hrs., 5, 10, 12, 14, 16, 17, 21, 28, and 49 days and for 6 and 12 months respectively. In most cases the work was done in duplicate and in critical stages, in triplicate.

Phase 2

Purpose: To study the use of bone chips in the regrowth of alveolar bone which has been surgically removed.

A detailed outline of the procedure used is enclosed in the fuller report.

Ten dogs were used in this investigation to allow histologic section at the following stages of healing: 11, 14, 20, 30, 35, 42, 49, 56, and 120 days. All work was done in duplicate. In addition, histologic sections of bone and soft tissue were secured to check on certain details of the procedure on both studies.x

C.H. Best
Signature

Date: January 18, 1949

x All specimens in Phase 2 are not yet completed for section.

APPENDIX "G"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: An investigation of the mechanics of repair of the supporting structure of the teeth.

Grantee: C.H. Best. (The work is done by Dr. W.J. Hinghorne.)

Project No.: D.R. 22 Amount of Grant: $ 2500.00

SUMMARY OF WORK

In the report to the last meeting of the Associate Committee the proposed work on this project was outlined under six headings. It was decided to concentrate first on Phases 1 & 2.

Phase 1

Purpose: To study the reattachment of the soft tissues to the tooth following surgical detachment of the soft tissues and the removal of a section of alveolar bone.

The procedure in this study is reported in detail in the full report.

Eighteen dogs were used in this investigation so as to allow specimens at the following stages of healing: 2½ hrs., 5, 10, 12, 1½, 16, 17, 21, 28, and 49 days and for 6 and 12 months respectively. In most cases the work was done in duplicate and in critical stages, in triplicate.

Phase 2

Purpose: To study the use of bone chips in the regrowth of alveolar bone which has been surgically removed.

A detailed outline of the procedure used is enclosed in the fuller report.

Ten dogs were used in this investigation to allow histologic section at the following stages of healing: 11, 1½, 30, 35, 42, 49, 56, and 120 days. All work was done in duplicate. In addition, histologic sections of bone and soft tissue were secured to check on certain details of the procedure on both studies.*

Date: January 18, 1949

C.H. Best
Signature

* All specimens in Phase 2 are not yet completed for section.

APPENDIX "G"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: An investigation of the mechanism of repair of the supporting structures of the teeth.

Grantee: C.H. Best

Project No.: D.R. 22 Amount of Grant: $2,200.00

Interim Report

In the report to the last meeting of this committee the proposed work was outlined under six headings. It was decided to concentrate first on Phase 1 and 2.

Phase 1

Purpose: To study the reattachment of the soft tissues to the tooth following surgical detachment of the soft tissues and the removal of a section of alveolar bone.

Procedure: The experimental animals were dogs. The following procedures were carried out under Sodium Pentobarbital anaesthesia, 35 milligrams per kilo weight.

(1) Smears of material were taken from the base of the gingival crevices on the teeth selected and were stained by Giemsa's method.

(2) The crevice depth was recorded.

(3) A line was made in the tooth at the gingival line by using a disc stone. This will be referred to as the gingival mark.

(4) A gingival flap was made about 20 mm. square, exposing the alveolar bone, care being taken to remove all the periostium as far as possible with the flap.

(5) A section of alveolar bone approximately 7 mm. by 6 mm. was removed, leaving about 12 mm. by 6 mm. of tooth exposed.

(6) In a number of cases the exposed tooth structure was thoroughly scaled, in others, no scaling of the teeth was done.

(7) The gingival flap was then sutured into place.

(8) After various time intervals (1 day to 12 months) had elapsed the animals were again anaesthetized. The clinical appearance was noted.

(9) Smears of gingival crevices were taken and stained as above.

(10) Recession of gingiva was recorded by measuring from the gingival line to gingival mark.

(11) A measurement from the gingival line to new line of attachment was recorded.

(12) In a number of cases a section of alveolar bone, approximately 5 mm. by 4 mm. was removed in one piece for sectioning to determine if any layers of the periostium still adhered to the bone.

(13) Also in seven cases the surgical flap was removed for sectioning to determine what periosteal layers were attached to the gingival flap.

(14) Eventually, at the conclusion of the experiment the teeth and periodontium were removed for sectioning.

Eighteen dogs were used in this study so as to allow specimens at the following stages of healing: 24 hours, 5, 10, 12, 14, 16, 17, 21, 28, and 49 days and for 6 and 12 months respectively. In most cases the operations were done in duplicate and in some cases in triplicate.

Phase 2

Purpose: To study the use of bone chips in the regrowth of alveolar bone which has been surgically removed.

Procedure: The same procedure as in Phase 1 was used in this study with the following exceptions:

(1) Before suturing the flap into place, the area from which the bone was removed was suitably packed with bone chips. Bone was secured from various places in the mouth.

(2) At different stages of healing, from 11 to 120 days, the dogs were again anaesthetized and the same procedures as in Phase 1 were carried out before the teeth and supporting tissues were removed for sectioning.

Ten dogs were used in this study to allow specimens at the following stages of healing, 11, 14, 20, 30, 35, 42, 49, 56, and 120 days. All work was done in duplicate.

Note: At the time of writing this report, some of the specimens for the longer intervals in Phase 2 are not yet ready for sectioning.

From these studies, when the sections at present being processed are available, we hope to have at least some of the answers to the following questions:

(1) Will the supporting tissues regenerate and become re-attached to the tooth after once being detached?

(2) What type of regeneration and reattachment occurs?

(3) What is the mechanism of healing and what part do the various cells and tissues play in the healing process?

APPENDIX "H"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March 1949

Subject: Entry of phosphate and carbonate salts into teeth as shown with the help of radio-phosphorus and radio-carbon.

Grantee: C. P. Leblond,
Professor of Anatomy,
McGill University.

Project No.: DR 23 Amount of Grant: $2,200.

SUMMARY OF WORK

The entry of radio-phosphorus into teeth was examined in rats of three different ages (newborn, growing rats of 50-60 g, fully grown rats of 240-280 g) and in newborn cats. The radio-phosphorus was estimated with the help of the Geiger counter and localized in histological slides with the help of the autographic technique.

In the newborn animals, the entry into the dentine is intense, especially in the zone of the dentine in contact with the odontoblasts. In contrast only a small amount enters into the enamel (Plate 1, Fig. 2).

In fully grown adult rats, two cases must be distinguished. In the molar teeth there is practically no deposition of new dentine (Plate 2, Figs. 3-8). In contrast the continuously growing incisor tooth shows an intense deposition of radioactive phosphorus close to the line of odontoblasts (Fig. 8). Incidentally, Figs. 3 and 4 were obtained from an animal sacrificed five minutes after injection. These figures reveal a marked deposition of radio-phosphorus in the zone of the alveolar bone in contact with the teeth. Similar observations may be made in Figs.4, 6 and 8.

In the growing rats both the alveolar bone and the zone of the dentine in contact with the odontoblasts showed an intense reaction.

The presence of similar intense reactions in the young dentine at all ages suggested that the mobility of the salts in this region must be extreme. Indeed,the measurements with the Geiger counter confirmed that its radioactivity was about equal to that of the blood plasma, and therefore the salts in this zone are readily exchangeable.

This conclusion may be extended to all bones and teeth since phosphate salts were found to be liable in all zones of growth.

APPENDIX "H-2"

Our results will be published within the next few months.

The work with radio-carbon is underway, but no definite results are available as yet.

Date: February 3, 1949.

C. P. Leblond
Signature

Plate I

Deposition of radio-phosphorus in the dentine of tooth germs of newborn cats 2 hours after injection of P_{32}.
(stained autograph above; unstained below)

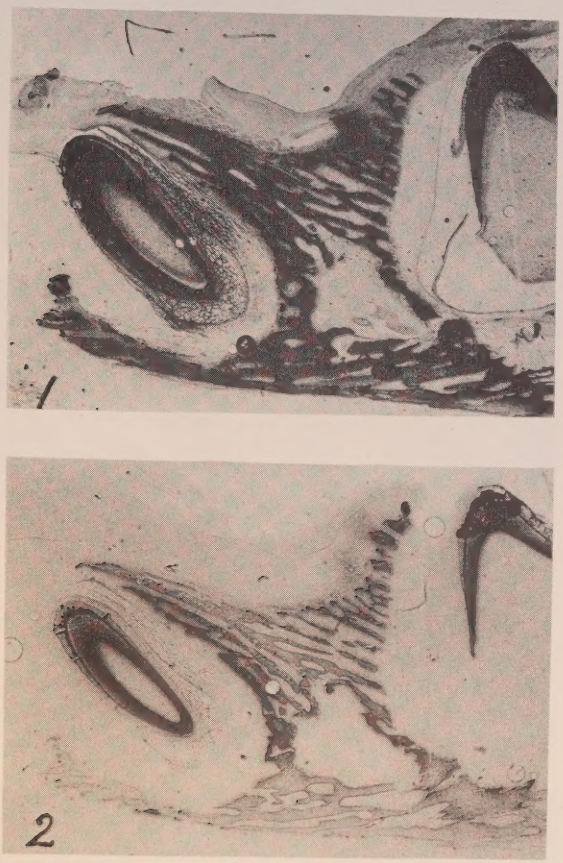


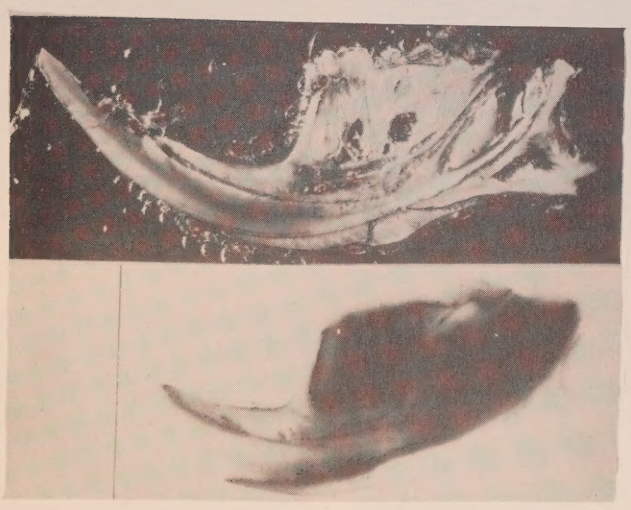
Plate II

Lower jaws of adult rats and corresponding autographs at various time intervals after injection of radio-phosphorus (x 4).

3

4

5 minutes



5

6

2 hours

7

8

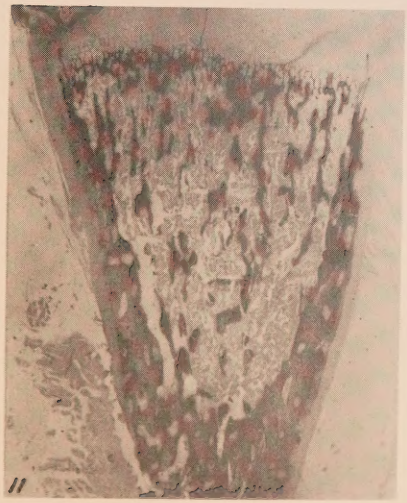
48 hours

Plate III

Long bones of newborn cats given radio-phosphorus, showing the predominance of the reaction in the area of most intense growth (epiphyseal plate)

9

10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APPENDIX "I"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March 1949

Subject: The effects of hard and soft diets on the supporting structures of the teeth.

Grantee: Dr. C.H.M. Williams

Project No.: DR 24 Amount of Grant: $1420.

SUMMARY OF WORK

In order to study the effects of the physical character of the diet on the supporting structures of the teeth in relation to periodontal disease, an animal experiment was set up in the following manner:-

Sixty rats were divided into two groups. One group is being fed a nutritionally adequate diet in a very hard form, while the other group is being fed the same food but which has been ground to a very fine powder and mixed with a certain quantity of water to make a gruel consistency. After the animals have been fed these diets for four months they will be sacrificed.

The gingival tissues, periodontal membrane, and the alveolar bone will be studied histologically, and one half of the mandible will be weighed and radiographed in the dry form.

The experiment was begun on the 13th October, 1948. The animals will be sacrificed over the period 4th February - 4th March, 1949.

Date: 30 January, 1949.

C.H.M. Williams
Signature

APPENDIX "I"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March 1949

Subject: The effects of hard and soft diets on the supporting structures of the teeth.

Grantee: Dr. C.H.M. Williams

Research Worker: Dr. D. G. Watt

Project No.: DR 24 Amount of Grant: $1420.

Many people believe that the physical character of the food and the manner in which it is eaten have an important influence on the growth and development of the jaws, and that the high incidence of dental disease is caused by soft, refined, non-stimulating diets. The following experiment is being carried out in order to study the changes, if any, in the supporting structures of the teeth as a result of a change in the physical consistency of the diet.

Sixty male and female rats, approximately three weeks old, were divided into two groups according to sex,- 32 males and 28 females. Then half the males and half the females were taken, at random, and fed hard Master Fox Breeder Cubes and the remainder were given the same food but which had been ground to a very fine powder and mixed with a certain quantity of water to make a gruel consistency. In order to ascertain the caloric intake of the two groups, four pairs of males and four pairs of females are being "pair fed". The remainder are being fed "ad libitum". The animals are weighed every week and it has been found that there is no significant difference between the weights of the "pair fed" rats and those fed "ad lib.", nor between the animals fed the hard diet and those fed the soft diet. Therefore, taking the gain in weight as the criterion for food consumption, it may be assumed that the caloric intake between the two groups is equal.

At various intervals during the experiment the skulls of some of the animals have been radiographed but no difference in the density of the bones could be established. However, after the animals have been sacrificed it will be possible to make a much better radiographic examination.

Also a bacteriological examination of the gingival crevice was attempted. Owing to the smallness of the crevice, it was found that it was impossible to take a

smear without contamination from other mouth organisms and also very little debris was noticed around the teeth. Such an examination would be better performed on larger animals.

After the animals have been fed the diets for four months, they will be sacrificed. This will be carried out over the period 4th February - 4th March, 1949. The mandible will be removed and one half will be stripped of all soft tissue. It will be radiographed and weighed in a dry state in order to study the relationship between the total weight and development of the bone and the degree of function to which it was submitted. The remainder of the mandible will be prepared for histological study and attention will be paid to changes in the following:

Gingival tissues:
(a) The degree of keratinization and the thickness of the epithelial covering.
(b) The nature of the epithelial attachment and its position on the tooth.
(c) The amount of inflammation present.
(d) The amount of calculus in the crevice.

Periodontal membrane: The thickness of the membrane and the arrangement of its fibres.

Alveolar bone:
(a) The ratio of compact to cancellous bone and the general architecture will be studied.
(b) The structure of the bone in relation to its muscle attachments.
(c) Inflammatory changes in the crest of the alveolar bone.

C. H. M. Williams
SIGNATURE

APPENDIX "J"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Investigation and critical report on dental caries research.

Grantee: Dr. J.S. Bagnall

Project No.: DR 7 Amount of Grant:

SUMMARY OF WORK

The survey of the Caries Literature is now practically complete. The literature on caries has been sub-divided under approximately 129 headings. The material in each division is arranged in chronological order. There still remains to be done some editing of this material to cut out duplication of statements. There will also need to be a number of cross references inserted. The literature has been pretty completely covered up to date although a few articles still continue to turn up. It is thought that this revision and overhaul can be completed within the next two to four months.

The bibliography of some 2000 odd items has been typed.

Date: February 4, 1949.

J. Stanly Bagnall
Signature

APPENDIX "J"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Investigation and critical report on dental caries research.

Grantee: Dr. J.S. Barnhart

Project No.: DR 7 Amount of Grant:

SUMMARY OF WORK

The survey of the caries literature is now practically complete. The literature on caries has been sub-divided under approximately 125 headings. The material in each division is arranged in chronological order. There still remains to be done some editing of this material to cut out duplication of statements. There will also need to be a number of cross references inserted. The literature has been pretty completely covered up to date although a few articles still continue to turn up. It is thought that this revision and overhaul can be completed within the next two to four months.

The bibliography of some 2000 odd items has been typed.

Date: February 8, 1949. J. Stanly Bagnall

Signature

Division Headings - Caries Research Review

1 - 2	Acid -	Formation in mouth.
1 - 4		In food and beverages.
3 - 2	Caries Lesions -	General.
3 - 4		In enamel.
3 - 6		Description of enamel lesion.
3 - 8		Pigmentation in lesion.
3 - 10		Process in dentin.
3 - 12		Location.
3 - 14		Examination for.
3 - 16		Caries indices.
3 - 18		Caries statistics.
3 - 20		Activity or susceptibility tests.
3 - 22		Familial similarity.
3 - 24		Seasonal, soil and sunshine factors.
3 - 26		Chemico parasitic theory.
3 - 28		Oral hygiene.
3 - 30		Experimental investigation.
3 - 32		Experimental animals.
3 - 34		In vitro caries.
5 - 2	Dentin -	Formation and structure.
5 - 4		Permeability and staining.
7 - 2	Diet -	Diet and caries.
7 - 4		Primitive diets.
7 - 6		Carbohydrates - chiefly sugar and starch.
7 - 8		Diabetes diet and caries.
7 - 10		Detergent diets.
7 - 12		Acid-base diets.
7 - 14		Breast feeding.
7 - 16		Inorganic requirements - Ca and P.
7 - 18		Ca and P level in blood stream.
7 -20		Rickets and caries.
7 - 22		Vitamins.
7 - 24		Vitamin A.
7 - 26		Vitamin C.
7 - 28		Vitamin D.
7 - 30		Vitamin K.
9 - 2	Enamel -	Calcification and formation.
9 - 4		Enamel structure.
9 - 6		Enamel cuticle.
9 - 8		Organic fraction.
9 - 10		Hardness.
9 - 12		Post eruptive changes
9 - 14		Surface protection against caries.
9 - 16		Solubility and decalcification.
9 - 18		Hypoplasia
9 - 20		Relation of hypoplasia to caries.

Division Headings - Caries Research Review

1 - 2 Acid - Formation in mouth.
1 - 4 In food and beverages.

2 - 2 Caries Lesions - General.
2 - 4 In enamel.
2 - 6 Description of enamel lesion.
2 - 8 Pigmentation in lesion.
2 - 10 Process in dentin.
2 - 12 Lesion.
2 - 14 Examination for.
2 - 16 Caries index.
2 - 18 Caries statistics.
2 - 20 Activity or susceptibility tests.
2 - 22 Familial similarity.
2 - 24 Seasonal, soil and curable factors.
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2 - 28 Oral hygiene.
2 - 30 Experimental investigation.
2 - 32 Experimental animals.
2 - 34 In vitro caries.

2 - 2 Dentin - Formation and structure.
2 - 4 Permeability and staining.

3 - 2 Diet - Diet and caries.
3 - 4 Primitive diets.
3 - 6 Carbohydrates - obiefly sugar and starch.
3 - 8 Diabetes diet and caries.
3 - 10 Deficient diets.
3 - 12 Acid-base diets.
3 - 14 Present feeding.
3 - 16 Inorganic requirements - Ca and P.
3 - 18 Ca and P level in blood stream.
3 - 20 Rickets and caries.
3 - 22 Vitamins.
3 - 24 Vitamin A.
3 - 26 Vitamin C.
3 - 28 Vitamin D.
3 - 30 Vitamin K.

4 - 2 Enamel - Calcification and formation.
4 - 4 Enamel structure.
4 - 6 Enamel cuticle.
4 - 8 Organic fraction.
4 - 10 Hardness.
4 - 12 Post eruptive changes
4 - 14 Surface protection against caries.
4 - 16 Solubility and decalcification.
4 - 18 Hypoplasia
4 - 20 Relation of hypoplasia to caries.

11 - 2 Enzymes -	General.
11 - 4	Amylase.
11 - 6	Phosphatase.
11 - 8	Urease.
13 - 2 Fluorine -	Mottled enamel.
13 - 4	Intake in diet and amount in foods.
13 - 6	In milk and saliva and placental passage.
13 - 8	Toxicity.
13 - 10	Storage and excretion.
13 - 12	Comparative amounts in teeth.
13 - 14	Union of fluorine with tooth tissue.
13 - 16	Effect on acid production in mouth.
13 - 18	Anti-bacterial action.
13 - 20	Anti-enzyme action.
13 - 22	Effect on tooth solubility.
13 - 24	Comparative caries data in F areas.
13 - 26	Theories on caries inhibition by fluoride.
13 - 28	Topical application of fluorides.
13 - 30	Prophylactic use, other than topical.
13- 32	Oral administration.
13 - 34	Addition to communal water supplies.
15 - 2 Hamster Caries -	General.
17 - 2 Isotopes -	
19 - 2 Microorganisms -	General.
19 - 4	Acid production in mouth by microorgs.
19 - 6	Census of mouth organisms.
19 - 8	In tooth tissues.
19 - 10	Reduction and inhibition of oral bact.
19 - 12	Reduction and inhibition of B. acido.
19 - 14	B. acidophilus or B. lactobacillus.
19 - 16	Nutritive requirements of B. acidophilus.
19 - 18	Streptococci.
19 - 20	Yeasts and molds.
19 - 22	Filamentous types.
21 - 2 Plaques -	General.
21 - 4	Plaque formation.
21 - 6	Formation of in vitro plaques.
21 - 7	Osmotic action.
21 - 8	Bacterial flora of plaque.
21 - 10	Enzyme systems of plaques.

11 - 2 Enzymes - General.
11 - 4 Amylase.
11 - 6 Phosphatase.
11 - 8 Urease.

13 - 2 Fluorine - Mottled enamel.
13 - 4 Intake in diet and amount in foods.
13 - 6 In milk and saliva and placental passage.
13 - 8 Toxicity.
13 - 10 Storage and excretion.
13 - 12 Comparative amounts in teeth.
13 - 14 Union of fluorine with tooth tissue
13 - 16 Effect on acid production in mouth.
13 - 18 Anti-bacterial action.
13 - 20 Anti-enzyme action.
13 - 22 Effect on tooth solubility.
13 - 24 Comparative caries data in ? areas.
13 - 26 Theories on caries inhibition by fluoride.
13 - 28 Topical application of fluorides.
13 - 30 Prophylactic use,other than topical.
13- 32 Oral administration.
13 - 34 Addition to communal water supplies.

15 - 2 Hamster Caries - General.

17 - 2 Isotopes -

19 - 2 Microorganisms - General.
19 - 4 Acid production in mouth by microorga.
19 - 6 Genus of mouth organisms.
19 - 8 In tooth tissue.
19 - 10 Reduction and inhibition of oral bact.
19 - 12 Reduction and inhibition of B. acidu.
19 - 14 B.acidofilus or B.lactobacillus.
19 - 16 Nutritive requirements of B. acidophilus.
19 - 18 Streptococci.
19 - 20 Yeasts and molds.
19 - 22 Filamentous types.

21 - 2 Plaques - General.
21 - 4 Plaque formation.
21 - 6 Formation of in vitro plaques.
21 - 7 Osmotic action.
21 - 8 Bacterial flora of plaque.
21 - 10 Enzyme systems of plaques.

21 - 12		pH of plaques.
21- 14		Removal of plaques.
21 - 16		Inhibitory action on plaques.
23 - 2	Pregnancy and caries -	
25 - 2	Rat caries -	Growth and development of teeth.
25 - 4		Calcification of teeth.
25 - 6		Calcification and caries.
25 - 8		Ductless glands.
25 - 10		Age and caries.
25 - 12		Carious and caries-resistant strains.
25 - 14		Similarity of rat and human caries.
25 - 16		Carious lesions in rats.
25 - 18		Diet and caries in rats.
25 - 20		Pigmentation in rat teeth.
25 - 22		Fluoride retention from diet and toxicity.
25 - 24		Caries inhibition by fluorides.
25 - 26		Microorganisms and rat caries.
27 - 2	Saliva -	Examination.
27 - 4		Activated and resting.
27 - 6		Differences in caries active and immune.
27 - 8		Rate of flow and volume.
27 - 10		Action of germicidal agents on saliva.
27 - 12		Anti-bacterial action of saliva.
27 - 14		Cells of saliva.
27 - 16		Oxidising and reducing power of saliva.
27 - 18		Saliva pH.
27 - 20		Buffer capacity.
27 - 22		Carbon dioxide capacity.
27 - 24		Composition - general.
27 - 26		Inorganic composition - general.
27 - 28		Inorganic constituents - Ca and P.
27 - 30		Inorganic calcium.
27 - 32		Inorganic phosphorous.
27 - 34		Composition - organic.
27 - 36		Sugar in saliva.
27 - 38		Ammonia and urea.
27 - 40		Amino acids of saliva.
29 - 2	Tooth Structure -	Calcification.
29 - 4		Composition.
29 - 6		Density.
29 - 8		Tooth structure - form.
29 - 10		Relation to caries.
29 - 12		Differences between carious and non-carious.

21 - 12 pH of plaques.
21- 14 Removal of plaques.
21 - 16 Inhibitory action on plaques.

23 - 2 Frequency and caries -

25 - 2 Rat caries - Growth and development of teeth.
25 - 4 Calcification of teeth.
25 - 6 Calcification and caries.
25 - 8 Ductless glands.
25 - 10 Age and caries.
25 - 12 Cariona and caries-resistant strains.
25 - 14 Similarity of rat and human caries.
25 - 16 Cariona lesions in rats.
25 - 18 Diet and caries in rats.
25 - 20 Pigmentation in rat teeth.
25 - 22 Fluoride retention from diet and toxicity.
25 - 24 Caries inhibition by fluorides.
25 - 26 Microorganisms and rat caries.

27 - 2 Saliva - Examination.
27 - 4 Activated and resting.
27 - 6 Differences in caries active and immune.
27 - 8 Rate of flow and volume.
27 - 10 Action of germicidal agents on saliva.
27 - 12 Anti-bacterial action of saliva.
27 - 14 Cells of saliva.
27 - 16 Oxidizing and reducing power of saliva.
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27 - 28 Inorganic constituents - Ca and P.
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27 - 34 Composition - organic.
27 - 36 Sugar in saliva.
27 - 38 Ammonia and urea.
27 - 40 Amino acids of saliva.

29 - 2 Tooth Structure - Calcification.
29 - 4 Composition.
29 - 6 Density.
29 - 8 Tooth structure - form.
29 - 10 Relation to caries.
29 - 12 Differences between various and non-carious.

APPENDIX "K"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario.

Grantee: M. Doreen Smith

Project No.: DR 13 Amount of Grant: $ 1,455.00

SUMMARY OF WORK

The preparation of media, sub-culturing, etc. for the microbiological analysis of fluorine was carried on by Miss S.R. Harness who replaced Mr. L.L. Winter as Assistant on this project in June 1948. Her results with this new technique checked with those of Mr. Winter. The most important improvement made on the method was a shortening of the incubation time from 72 to 24 hours by the use of a so-called "heavy inoculum". Since the method appears useful for the analysis of a large number of water samples at a time, it is proposed to submit a paper to the Council for appraisal with a view to publication.

Analysis of teeth microbiologically presents a problem due to the difficulty in getting the fluorine into soluble form at the pH of the medium. Five approaches were made to overcome this. (1) Solution in strong acid followed by adjusting to optimum pH. Fluorine came down with the phosphate precipitate. (2) Use of colloidal agents to hold phosphate-fluorine complex in the colloid state. Unsuccessful. (3) Fusion of the tooth by a fusion mixture, followed by solution - again 75% of the fluorine precipitated probably with the calcium carbonate. (4) Distillation followed by microbiological analysis instead of titration. This gave satisfactory results and eliminated the titration step of the regular chemical method, but is possibly no improvement in accuracy. (5) The whole tooth was ground and added directly to the medium. It showed inhibition but not to the extent expected by the amount of fluorine present. A sixth method using ion exchangers is at present being explored.

About 30 teeth with accompanying data have been received to date from Kitchener and Stratford in reply to requests. These are continuing to come in and analysis for fluorine is being made (using the chemical method) on these teeth. By the end of March it is expected that a good many will be completed. A number of teeth are being received from other areas which also are being analyzed.

Sixty-nine teeth have been received from Dr. H.K. Brown in connection with his surveys. These are being separated into enamel and dentin fractions and fluorine analysis carried out on each sample. The separation is being made by the method of Manly and Hodge.

Date: February 7th, 1949

M. Doreen Smith
Signature

APPENDIX "A"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario.

Grantee: M. Doreen Smith

Project No.: DR 13 Amount of Grant: $ 1,450.00

SUMMARY OF WORK

The preparation of media, sub-culturing, etc. for the microbiological analysis of fluorine was carried on by Miss E.M. Harness who replaced Mr. L.L. Winter as Assistant on this project in June 1948. Her results with this new technique checked with those of Mr. Winter. The most important improvement made on the method was a shortening of the incubation time from 72 to 24 hours by the use of a so-called "heavy inoculum". Since the method appears useful for the analysis of a large number of water samples at a time, it is proposed to submit a paper to the Council for appraisal with a view to publication.

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Date: February 7th, 1949 M. Doreen Smith

Signature

APPENDIX "K"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario.

Grantee: M. Doreen Smith

Project No.: DR 13 Amount of Grant: $ 1,455.00

During the past year studies have continued on the application of the microbiological technique of quantitative fluorine analysis to teeth.

In June 1948 a new assistant Miss S.R. Harness replaced Mr. L.L. Winter on this project. Her results when using the new method checked with those obtained by Mr. Winter. The strain of L. Acidophilus obtained from a carious mouth was carried on as a test organism, as it continued to respond well to inhibiting concentrations of fluorine from 3 - 20 p.p.m. a satisfactory range for work with teeth.

Guirard et al[1] have stated that in addition to its role as a buffer in the growth medium, acetate may also have a function concerned with the initiation of growth of lactic acid bacteria. Thus it was decided to make up a medium having additional sodium acetate in the form of a sodium acetate-acetic acid buffer. This medium, although it produced better growth as estimated by greater acid production, was not as sensitive in its reactions to inhibitory concentrations of fluorine, therefore, the addition of this extra sodium acetate was not considered necessary.

Analysis of Teeth Microbiologically

In applying the microbiological method of analysis to teeth the problem is to get the fluorine into ionic solution, if possible, before testing its action upon the microorganisms. The first idea was to dissolve the tooth in acid and then to adjust it to a suitable pH (5.1). Acetic acid and several mineral acids were tried. It was found that 20 ml. of 10% HCl would dissolve a 0.5 gm. sample of tooth in 24 hours leaving insoluble organic matter probably the protein found by Muhler[6]. Sulphuric acid and acetic acid were not as satisfactory as hydrochloric.

Since small amounts of fluorine are believed to exist in the enamel and dentin as Apatite ($3\ Ca_3\ (PO_4)_2\ .\ Ca\ F\ Cl$), it is probable that this complex is broken when treated by the strong acid. In any case a clear solution was obtained in the hydrochloric acid, but the pH has to be adjusted before testing on the microorganisms. When the pH was brought into the alkaline range a voluminous white precipitate formed. This was deduced to be chiefly phosphates from an examination of the chemical composition of teeth and the fact that the precipitate gave a strong qualitative test for phosphate.

It is possible to adjust the pH as high as 4.2 without the precipitate forming but on raising it to 5.1 a slight precipitate is obtained, and when this is followed by the necessary step of autoclaving with or without the medium, a further precipitation occurs.

An experiment was made to learn whether the fluorine was in solution or adsorbed on the precipitate. A number of teeth were dried at 100° C. for two days then ground up using a diamond mortar and pestle and mixed together to form a pooled sample, and then re-dried for two hours at 100°C. Two aliquots were taken. The first was weighed into a platinum crucible, ashed and fluorine analysis made by the modified Willard and Winter[2] chemical method. The second aliquot was dissolved in 10% HCl. It was then made just alkaline to phenolphthalein and a voluminous white precipitate formed. This was filtered through a fritted glass filter and rinsed with flurine free distilled water. It was then dissolved in perchloric acid and analyzed by the chemical method for its fluorine content. Approximately three quarters of the total fluorine content was found to be in the precipitate.

Since the removal of the precipitate by simple filtration was not practicable, it was thought that it might be possible to disperse the precipitate into the colloidal range by some means, assuming the fluorine in this form might be effective on the microorganisms. Solutions were made up using different protective colloidal substances in varying concentrations. Milk, gelatin, gum arabic and agar were some of the materials used. With gum arabic the solution appeared to remain almost clear until the tubes were autoclaved. This again caused a precipitate to settle out.

Two chemical techniques were proposed for obtaining the fluorine in a solution free from other interfering substances:

(a) Distillation
(b) Fusion

Actually distillation is used in the regular chemical method of analysis. The distillate instead of being titrated with thorium nitrate and potassium fluosilicate could be concentrated to an effective range (by evaporation of the solution made alkaline) and the fluorine content determined microbiologically. This was done, the results checking fairly well:

0.0363% fluorine for chemical method
0.0340% fluorine for microbiological method

The error ascribed to the chemical method is felt to be due to the titration procedure rather than to incomplete distillation[3]. Thus a method which would eliminate the titration might be desirable. However, it is doubtful whether any biological technique would have a smaller error.

By using the fusion technique it was felt that the calcium of the insoluble calcium phosphate could be replaced by sodium or potassium giving rise to soluble phosphates. After several trials a eutectic mixture of sodium and potassium carbonate was devised to be used as the fusion mixture. Two gms. of anhydrous sodium carbonate were mixed well two gms. of potassium carbonate. One half of this mixture (finely powdered) was placed in a platinum crucible. Then a half gm. sample of powdered tooth was mixed with the flux and the remainder of the mixture sprinkled on top. The crucible was heated gently at first and then more strongly. As soon as the mass had melted quietly and the black colour due to carbon had disappeared the decomposition was felt to be complete. The melt was removed from the crucible into a beaker where it was leached with water. Most of the solid melted on heating, but a certain amount of precipitate remained which did not dissolve. This was presumably calcium carbonate. The solution was filtered, the precipitate being washed several times with M/10 sodium carbonate. Since a considerable volume of solution was obtained by this procedure it was decided that it would be easier to analyze the precipitate (the residue on filtration) for fluorine by the chemical method than to evaporate the filtrate down and analyze it for fluorine. The precipitate was accordingly dissolved in perchloric acid, distilled and titrated. The precipitate was estimated to contain about 70% of the total fluorine content originally present. This experiment was repeated to see if the technique could be improved but a considerable amount of the fluorine still remained in the precipitate.

It was next decided to try adding the tooth itself in a finely powdered form in the hope that the assay medium, which was at a slighly acid pH, might under the influence of autoclaving free the fluorine into solution so that it could inhibit the lacto bacilli. A certain amount of inhibition was

produced but not the degree that should be produced if all of the fluorine present in the tooth were acting on the organisms.

The method which we are at present examining to obtain a solution containing the fluorine from teeth in a suitable form for the microbiological method is one involving ion exchange resins. So far we have merely experimented with the acid adsorbent or an ion exchange resin IR - 4B (Rohm and Haas Company - The Resinous Products Division, Philadelphia) which theoretically should preferentially adsorb the phosphates as phosphoric acid from an acid solution of the tooth leaving the fluorine in the effluent. There is the possibility of passing the solution of the tooth through a two or three column series of different exchanges which would give a purer solution of the fluorine. So far we have experienced difficulty in making this scheme quantitative but it is still being considered.

Improvement in the Microbiological Method for Water Analysis

Concurrent with the above experiments on preparation of teeth for fluorine analysis, experiments were carried out to shorten the incubation period for the micro-method.

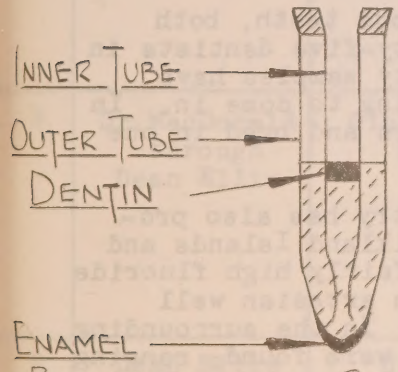
It was decided to try the use of a so-called "heavy inoculum" instead of the simple inoculation of culture organisms used in microbiological technique. This "heavy inoculum" is prepared as follows: 50 ml. centrifuge tubes, each containing 25 ml. of inoculum broth were used. Eight of these could be centrifuged simultaneously if necessary. As before, loopfuls of the organism were transferred to the sterile tubes containing 25 ml. of basal medium. These were incubated at 37.5°C. for twenty-four hours, the tubes were then centrifuged a half hour, the supernatant decanted and the organisms resuspended in 10 ml. of sterile saline. When resuspension had been effected with the aid of a sterile pipette, the suspensions from all tubes were poured into a sterile 100 ml. flask and agitated until uniform. In this instance assay tubes were inoculated with 0.5 ml. of heavy inoculum from a graduated 10 ml. pipette.

At first it was hoped that a six hour incubation period would show sufficient inhibition by the fluorine to be useful in the quantitative determination of the element. However it was decided that a twenty-four hour incubation period was more convenient and gave more reliable results. This made it possible to set up the tubes for the run on one morning and titrate them the next. This method gave quite good results for aqueous solutions containing known amounts of fluorine.

While the time required for carrying out one determination by this technique is still much longer than the chemical method, if a number of determinations are to be made the reverse might be true. No economic comparison of the two methods has been made, but it is felt that the microbiological technique should be practical where large numbers of determinations are being made on water and it is planned to submit a paper to the Council on the method as accelerated by "heavy inoculum", with a view to publication.

Separation of Enamel and Dentin

During a visit from Dr. H.K. Brown (July 2, 1948), it was agreed that we would endeavour to analyze teeth supplied by him in connection with the surveys he is making. He believes that it is important to analyze the enamel and dentin separately for fluorine and accordingly, methods for the separation of teeth into these two fractions were studied. The method reported by Manly and Hodge[4] in 1939 seemed the most promising and so was investigated. The method depends on a difference in density between enamel and dentin, the two being separated by centrifugation.



The type of apparatus used in the separation is shown on the left. 8 ml. of a mixture of 91 volume per cent bromoform and 9 volume per cent acetone are placed in the outer tube and the inner tube introduced. (Other liquids may be used as long as the density 2.70 is obtained). The powdered tooth (weighed) is added through a powder funnel to the top of the liquid within the inner tube. The upper portion of the tube is stirred gently to wet the powder completely and to break up any adhering particles. The layers are separated by centrifuging tne entire assembly for two minutes at 2200 r.p.m. This separation when completed gives an enamel of 99% purity and a dentin which is 97-99% pure according to the authors.

This procedure was carried out on a sample of tooth weighing 0.6814 gm. After the separation 0.1976 gm. of enamel and 0.4813 gm. of dentin were obtained. The enamel and dentin totalled 0.6789 gm. or a loss of .0025 gm. in the separation. This appears to be a satisfactory and workable method. Sixty-nine teeth from fifty-three children with records have just been

received and some figures on these should be ready for Dr. Brown before the end of March. It is decided to use the chemical assay on these samples until more progress is made with the microbiological method.

Analysis of Teeth from Several Areas in Ontario

Since it was desirable to analyze teeth from different areas in Ontario where the fluoride content of the drinking water varies, it was decided to proceed using the chemical analysis. An experiment was done to estimate the recovery of added fluorine to teeth. Two 0.5000 gm. samples of a pooled sample of teeth were weighed out into platinum crucibles. To one was added 50 μg of fluorine in aqueous solution. Twenty-five per cent magnesium acetate solution was used as a fixative and both samples were ashed and analyzed for fluorine.

% F. in Teeth	- .0386
F_1 added in μg	- 50
F_1 recovered μg	- 51
F_1 recovered %	- 102% (This is within the error of the method.)

Requests for carious and non-carious teeth, both primary and secondary were sent out to twenty-five dentists in Kitchener and ten in Stratford. About thirty samples have been received to date and these are continuing to come in. In each case the teeth are from individuals born and bred in one or the other of these cities.

The Dean of the Faculty of Dentistry has also provided us with a number of teeth from the Falkland Islands and two teeth from Ripley, Ontario, which is a fairly high fluoride area. Ripley Village gets its water from an artesian well with a fluorine concentration of 1.0 p.p.m. In the surrounding countryside lower and higher concentrations were found, ranging from 0.23 to 1.69 p.p.m.(5)

Results obtained so far are given in the table on the following page.

CHEMICAL ANALYSIS OF FLUORINE IN TEETH

Anal. No.	Received from	Patient and District	Age	Tooth Analysed	Description Remarks	%F
1	Dr. H. W. Baker	Miss M. Bartlett STRATFORD	42	permanent bicuspids (pooled sample of 2 teeth)	non-carious	0.0398
2	Dr. S. H. Sutter	Glen Lindesmith STRATFORD	7½	permanent first molar U.R.	partly decalcified but not severely carious	0.0314
3	Dr. MacDonald through Dean Ellis	Dr. MacDonald's child RIPLEY	not given child	deciduous molar	The crown only was analyzed - the roots of the tooth apparently having been physiologically resorbed. Not carious although there was a brown spot at one side.	0.0120
4	Dr. MacDonald through Dean Ellis	Glen Frazer Ripley	15	permanent molar	carious but tooth also exhibits dental fluorosis as did the other teeth in the child mouth.	0.0714
5	Dean Ellis through Dr. Rae	Unknown FALKLAND ISLANDS	not given	permanent central incisors Upper	large non-carious teeth	0.0529

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4. Manly, R.S. and Hodge, H.C., J. Dent. Res., 18, 133, 1939.
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M. Doreen Smith

CHEMICAL ANALYSIS OF FLUORINE IN TEETH

Anal. No.	Received From	Patient and Address	Age	Tooth	Description of Sample	%
1	Dr. R.W. Baker	Miss M. Sutcliffe STRATFORD	42	Bicuspid (Lower)	2 Teeth)	0.0254
2	Dr. B. Butler	Mrs. L. Lissaman STRATFORD	71			0.0218
3	Dr. MacDonald	Dr. MacDonald RIPLEY				0.0140
4	Dr. MacDonald	Dean Ellis through Dr. Rae RIPLEY				0.0214
5	Dean Ellis	Unknown FALKLAND FALKLAND				0.0259

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APPENDIX "L"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries.

Grantee: M. Doreen Smith

Project No.: DR 14 Amount of Grant: $1,500.00

SUMMARY OF WORK

Before determining the amount of fluorine in milk obtained from high and low water fluorine areas, water samples from each district were analyzed in February, March and April 1948. The results checked with figures already available on these districts. The results of the fluorine analyses on milk indicate that samples from a high water fluorine district have statistically more fluorine than milk from a low water fluorine area.

In an attempt to determine the effect of atmospheric fluorine on the fluorine content of vegetation, spinach was grown in an atmosphere high in fluorine and in the same soil, in one lower in fluorine. Leaves and grass from these areas were also analyzed for fluorine. These were compared with products from a rural area. Magnesium oxide was used as an absorption agent in the determination of atmospheric fluorine.

Source (Aug.)	Microgm. fluorine 5 gm. MgO	Fluorine content p.p.m. dry wt.		
	Atmospheric Fluorine	Spinach	Leaves	Grass
Glass Factory	425	154,169	86,78	75,78
Control	129	112,117	26,18	30,31
Rural	-	66, 32	-	-

From these results it appears that vegetation from an area high in atmospheric fluorine is higher in fluorine than that from an area lower in atmospheric fluorine.

The analysis of leaves was repeated in October. The fluorine content of those from the rural area remained low, but those from the control area were higher in fluorine than those from the glass factory. This may be partially explained by the fact that the glass factory had ceased to make high fluorine glass and the amount of smoke due to heating plants in the control area had increased. Also the

(SUMMARY) "L-2"

leaves from the control area were collected during particularly foggy weather, weather which at the same date was believed to have contributed to the death of nineteen persons in Donora, Pa., U.S.A., where fluorine is given off in the process of making zinc. An attempt to obtain information concerning the fluorine content of the atmosphere at this time gave inconclusive results.

Fresh imported and canned spinach were analyzed for comparison with above results and also a number of other food products including baby foods, tea and a mixed diet. The high fluorine content of pablum and of tea is especially interesting cheap tea showing more fluorine than expensive tea. The meal analyzed contain approximately 0.15 mgm. fluorine without beverage. With a half pint of milk this would total 0.17 mgm. fluorine and with one cup of tea (fluorine-free water) approximately 0.35 mgm.

Further investigations of mixed diets for a whole day seem of value and it is expected more of this data will be obtained by the end of the fiscal year. This should give an idea of what daily fluorine intake might be expected in addition to that from water.

February 4th, 1949 M. Doreen Smith

APPENDIX "L"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries.

Grantee: M. Doreen Smith

Project No.: DR 14 Amount of Grant: $1,500.00

The cities of Kitchener and Stratford were chosen as suitable areas for this study. Samples of their communal water supplies were analyzed once a month for three consecutive months.

Month	Fluorine Content p.p.m.	
	Kitchener	Stratford
February	0.16, 0.13, 0.12	1.25, 1.27
March	0.19, 0.16	1.31, 1.28
April	0.17, 0.17	1.29, 1.33

The results appear consistent over the three months studied and indicate that Stratford water has a fluorine content which is almost optimum, while Kitchener water has a low fluorine content.

It seemed of interest to compare the amount of fluorine contained in food from high and low water-fluorine areas. Milk was chosen for analysis since it is a general food consumed particularly by children, the group most affected by fluorine. In addition, McClendon and co-workers (Archives Biochem., 1:51, 1942) found an inverse ratio between the fluorine content of the milk supply and the incidence of dental caries. Smith, Vavich and Smith (Univ. of Ariz. Agr. Exp. Station Bulletin No. 77, 1945) found that even when cows were given high concentrations of sodium fluoride in their drinking water (up to 500 p.p.m.) the fluorine was not transmitted in large quantities to the milk, but were largely excreted by the kidneys. However the fluorine content of the milk rose from 0.0 - 0.3 p.p.m. when fluorine content of the drinking water rose from 0.2 - 3.0 p.p.m. Hart and Elvehjem (Ann. Rev. Biochem. 5:271, 1936) state that the fluorine content of milk is unaffected by the ingestion of fluorides.

The fluorine content of homogenized milk from three dairies in each of Kitchener and Stratford was determined for three consecutive weeks.

City	Dairy	Fluorine Content p.p.m. 1st week	2nd week	3rd week
Kitchener (April)	Silverwoods	0.03, 0.04	0.13	0.11
	Westside	0.03	0.08	0.09
	Maple Grove	0.04	0.12	0.09
Stratford	Avon	0.09	0.16	0.17
	Finnegans	0.14	0.13	0.17
	Silverwoods	0.11	0.11	0.16

Toronto milk (Donlands homogenized) had fluorine content of 0.06 p.p.m. fluorine as an average of three determinations. From these results it may be seen that although the fluorine content of milk is quite low, milk from a high water fluorine district contains statistically (X) more fluorine than milk from a low water fluorine area. A recent paper by Churchill and co-workers (J. Ind. Eng. Chem. Anal. 20: 69, 1948) suggested that the absorption of atmospheric fluorine is an important factor in the total amount present in vegetation. To investigate this aspect spinach was grown close to a glass factory which was using cryolite and fluorspar in its formula. As a contrast, spinach was grown in the same soil in a location where the fluorine content of the atmosphere was lower. In each case the spinach was grown in a box and watered with fluorine-free water. The two lots were compared with spinach grown in a rural area. The relative amounts of atmospheric fluorine were determined by means of magnesium oxide filters. (Elvove, Pub. Health Reports 52: 1308, 1937). The magnesium oxide in 200 mesh copper sieves was placed in a convenient position in the several areas for a forty-eight hour period. The resulting magnesium oxide was then dried and analyzed for fluorine.

(X)

Analysis of Variance (2nd and 3rd weeks)

Source of Variation	Degrees Freedom	Sum of Squares	Mean Square
Total	11	0.0107	0.0010
Between Milks	1	0.0061	0.0061*
Within Milks	10	0.0046	0.0005

* Significant at 1% level.

Source	Mag. oxide filters micro-gms. fluorine/5 gm. MgO	Fluorine content p.p.m. dry wt.
Glass factory	425	154, 169
Control	129	112, 117
Rural		66, 32

These results indicate that atmospheric fluorine affects the fluorine content of vegetation.

Poplar leaves and grass from these areas were also analyzed for fluorine.

Grass (Aug.)

Location	% Moisture	Fluorine(p.p.m. dry wt.)
Glass Factory	38.4%	75, 78
Control	46.7%	30, 31

Leaves

Location	August		October	
	%Moisture	Fluorine (P.P.M. dry wt.)	% Moisture	Fluorine (p.p.m. dry wt.)
Rural			70.2%	22, 26
Glass Factory	54.7%	86,78	83.0%	96,106
Control	68.4%	26,18	82.9%	164,166

The results obtained in August indicate that vegetation from an area high in atmospheric fluorine is higher in fluorine than that from an area lower in atmospheric fluorine. The analyses of leaves made in October, however, gave opposite results. This may be partially explained by the fact that the glass factory had ceased to make high fluorine glass. The leaves from the control area were collected during a period in which there was a heavy fog over the city and this may have influenced the results. It is interesting to note that a high concentration of atmospheric fluorine during similarly foggy weather at the same date is believed to have contributed to the death of nineteen persons in Donora, Pa., U.S.A., where the gas is given off in the process of making zinc. It should also be noted that the amount of smoke due to heating plants in the control area (hotels, hospitals, museum, university and government buildings) had increased at this time of year. (H. M. Barrett, Can. Public Health Jour., January 1938).

An attempt was made to obtain an idea of the relative amounts of atmospheric fluorine in the areas concerned at this time, as had been done previously, but the results were inconclusive. It is felt that further work on absorption agents is necessary.

Since the spinach analyzed contained a large amount of fluorine, a sample of fresh spinach from the market was examined. The fluorine content of canned spinach was also determined.

Spinach (November)	Fluorine (p.p.m. dry wt.)
Fresh (imported	1.7, 1.2
Canned	4.0, 4.6

Winter and Butler (Jour. Assoc. Off. Agr. Chem: 16, 105, 1933) give the fluorine content of spinach (dry substance) as 0.30 - 8.60 p.p.m. fluorine.

However, Dr. Morris Katz, Defence Research Laboratories, Ottawa (private communication) states that "the amount of fluorine present in the leaves of most plants growing in an uncontaminated atmosphere is usually less than 25 - 50 p.p.m. If the fluorine content rises much higher, to several hundred or more parts per million in the leaves, one may suspect the presence of fluorine compounds in the atmosphere."

Since fluorine is effective in the prevention of dental caries chiefly in infants and children, a number of baby foods were analyzed.

Foods	Fluorine(p.p.m. dry wt.)
Heinz strained spinach	6.8, 8.2
Heinz strained carrots	0
Heinz strained beans	0.06, 0.10
Pablum	13.7, 12.2, 12.6

The high fluorine content of Pablum is particularly interesting.

In an attempt to determine the amount of fluorine in a mixed diet, a meal which might be expected to contain a rather considerable amount of fluorine was analyzed(containing spinach and fish).

1 small glass tomato juice
1 serving halibut and white sauce
1 serving mashed potatoes
1 serving spinach
1 white roll
1 pat butter
1 piece apple pie

Fluorine content - 0.92, 1.04 p.p.m. dry wt.

This meal thus contains approximately 0.15 mgm. fluorine.

Since beverage was not included in this meal infusions of cheap and more expensive tea were analyzed for fluorine (using fluorine-free water in the infusion).

	Fluorine, micrograms/100 ml.
Cheap tea	117.0, 126.6
Expensive tea	105.3, 91.6

Thus an infusion of tea provides approximately one part per million of fluorine, which is the optimum content for water. Cheap tea appears to contain more fluorine than expensive tea which Reid (Chinese Journal of Physiology 70:259, 1936) suggests is due to age but more analyses would be needed to confirm this. Thus a meal (as above) plus one half pint of milk has a fluorine content of approximately 0.17 mgm. fluorine. If one cup of tea were substituted for the half pint of milk the fluorine content would be approximately 0.35 mgm. fluorine.

It is intended to determine the fluorine content of coffee and also to obtain further data on mixed diets for a whole day. This should be completed by the end of March and a paper will be submitted on the material with a view to having it assessed for publication.

The chemical method as outlined in "Methods of Analysis of the Association of Official Agricultural Chemists, 1945", with certain modifications, was used in all fluorine determinations.

February 4, 1949

M. Doreen Smith

APPENDIX "M"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March 1949

Subject: An Anatomical, Histological and Physiological Study of the Temporo-Mandibular Joint.

Grantee: Richard J. Godfrey, D.D.S., M.Sc.(Dent.)

Project No.:DR 11 Amount of Grant: $2550.

SUMMARY OF WORK

The report deals with the following topics in detail:

1. Our present knowledge leads us to believe that the previous experiments in placing jaws of rats out of function were not conclusive because function of the incisors was permitted thereby distributing forces throughout the entire mandible.

2. An antomical description of the squamoso-mandibular joints of the rat pointing out the specialized character of each part.

3. A discussion of the synovial fluid pointing out elements of greater viscosity and a discussion of how some of these elements are manufactured or brought into the fluid.

4. Epithelium is found to be present in the joint. This fact may be debated but reasonably conclusive evidence is presented in the sections.

5. A specialized blood vessel has been discovered which appears to be directly concerned with the chemistry of the joint. This vessel is unlike the normal appearance of blood vessels of similar size.

6. Mast cells were found to stain blue in areas of function and to stain red in areas of rest.

7. In the appendix is found some conjectures about enzymes, autolysis and fat.

Date: February 7, 1949.

Charles H. Moses
Signature
Research Assistant.

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REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

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Date: February 7, 1949. Charles H. Keyes

Assistant

Research Assistant.

APPENDIX "M"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: An Anatomical, histological and physiological study of the temporo-mandibular joint

Grantee: Richard J. Godfrey, D.D.S., M. Sc.(Dent)
Research Assistant: Charles H. Moses, D.D.S., M. Sc.(Dent)

Project No.: DR 11 Report No. 5. Amount of Grant: $2550.

Critical Comments on our Previous Work

Clinical experience and studies lead one to believe that alterations of some of the structures of the temporo-mandibular joint take place when some of the teeth are extracted. New habits and mechanical forces bring about greater loading of some of the tissues in some areas and diminished loading in others.

Due to the fact that apparatus by means of which observations of altered structures were to be made upon human beings had not been delivered to the Faculty, studies upon animal material were initiated. Posterior teeth were extracted on one side of either one or both jaws of white rats. Observations were made macroscopically, microscopically, chemically and by means of X-Rays. These studies have been reported upon from time to time in previous reports.

The results were not as apparent as we had anticipated. The only visible alteration observed was when the Alizarine Red S. was added to the rats' diet. New growths of the bone stain red and new deposits of bone were laid down in some sections while other areas such as the bone under the extracted teeth, for instance, showed no deposits.

Experience in experimental methods cannot be minimized. It would have saved us much time had these experiments been discussed before and during the time they were performed.

We were aware that the incisors of rats continuously erupt and were prepared to clip them if they grew too long because of their inability to eat food when the extraction of posterior teeth took place. Since the rats immediately took to the food offered and since the incisors did not grow too long but apparently received normal wear, we immediately forgot about the precautions.

It did not occur to us or to anyone else whom we consulted or had we seen it reported that the rats habitually gnaw on their cages. This not only wears their incisors but transmits forces throughout the major portion of the mandible. The incisors seem to have more tooth structure than the rest of the mandibular teeth combined. (Fig. 1) The roots run through the length of the body of the mandible and part of the ramus. Forces at the incisal edge are therefore transmitted throughout the mandible and although some loss of function takes place when molars are extracted, this is difficult to estimate because forces are transmitted to the bone directly underneath the extracted molars.

The experiments would have been performed in a more ideal manner had the incisors not been permitted to function. Even glass tubes through which the rats obtain drinking water should be eliminated because they might be used to exercise the teeth. It is our intention to repeat our experiments under more favorable and exact conditions.

Partial Anatomical and Physiological Description of the Mandibular Joint of the White Rat

We are careful not to say temporo-mandibular joint because in the rat the condyle of the mandible articulates with the squamosa. Thus in the rat it is actually a squamoso-mandibular joint.

The joint is of a ginglimo-arthroidal character having both the hinge action which is characteristic of carnivorous animals and the sliding action which is characteristic of the herbivorous animals. Like all rodents the rat has a long antero-posterior movement and the bones are consequently shaped to accommodate this predominating movement. The condyle and the fossa are therefore longer antero-posteriorly than lateral-medially. The shapes and wear noticed on the posterior teeth indicate that there is a lateral movement but manipulation of the skull would indicate that this movement is limited and is certainly not as great as the antero-posterior one.

When the rat occludes upon his posterior teeth his incisors do not contact, the uppers being anterior to the lowers. When he slides forward, meeting the incisal edges of his anterior teeth, the posteriors are completely out of contact. This led Collins, Becks, Simpson and Evans[1] to observe that the fossa has two levels to accommodate the two levels of occlusal contact. We have not discerned two levels in our rats. We believe that a better explanation would be that as the mandible separates from the upper jaw because of the different levels of the occlusal surfaces of the posterior teeth and the incisal edges of the anterior teeth, a rotation of the condyle takes place as the condyle travelled forward, permitting the jaws to separate.

One cannot give a complete anatomical description of the joint without noting that there are physical differences in every portion of the joint. The anterior portion is different to that of the posterior portion and the structures in the lateral portion are different from those in the medial portion. This becomes easier to understand when we note that there are different physiological functions performed in each section both of a physical and chemical nature.

It would be better, then, to point out differences in a general manner at the outset and specifically later on. For this reason, therefore, we shall show low-power sections in the sagittal and frontal (or transverse-vertical) planes and then both high and low power serial sections in three planes - sagittal, frontal and horizontal. The location of the section, whether anterior or posterior, or whether lateral or medial will determine what the structures and their relationship will be. Thus, when a sagittal section of the joint is illustrated the location of the section is important because the medial structures of the sagittal section are different from those of the lateral ones.

(Fig. 2) shows a low power sagittal view of the joint. The upper articular bone (A) (squamosal) is shown as is a portion of the condyle (F) cartilaginous tissue. Separating both bones but conforming to their shapes is a fibro-cartilaginous meniscus or disk. In some sections spaces appear between the articulating surfaces of the bones and the disk but these are probably due to shrinkage artefacts. In other sections the disk hugs the articular surface of the bone so closely that even microscopically they appear to be one tissue. Of course there is synovial fluid present on both sides of the disk and completely separated by it making it possible for the constituents of each fluid to be self contained. Due to the presence of this fluid, therefore, too much emphasis should not be placed upon artefact because it could easily be possible for more fluid to collect in some areas than others because of the movement of the mandible. Fig. (3) is a higher magnification showing the histological structures of the disk, at or near the articular surfaces.

Further investigation of the joint in Fig. 2 shows that there is a difference in the structure of the tissues above the disk from those below the disk. Furthermore, in the upper part the posterior portion is quite different in structure from the anterior portion. Fig. 2(C) shows some villi in a tissue shaped to correspond to that corner of the joint. It is our belief that these villi are parts of a secretory mechanism. Since this posterior portion of the

joint is non articulating in the strict sense, it is not fibro-cartilaginous. The posterior part of the joint is the least active. Beyond a piston-like pumping action of the fluid and the tissues, it does not receive direct pressures.

Nature develops specialized tissues for specialized needs. We shall subsequently indicate the specialized character of this tissue. At the anterior part of the upper portion are symmetrical rows of fat cells. The anterior direction of muscular pull can be noticed by the direction and insertion of the muscle fibres in the condyle and the disk.

Fig. 4 shows a frontal view of the condyle. It should be noted how closely the disk hugs the upper articular surface and how much thinner it is in the articulating area as against the non-articulating area. The condyle has a limited ability to move. Its motion is chiefly a rotating one. Being attached to the disk it cannot slide very much within the disk but is permitted to rotate, and this in fact is the independent movement of the condyle - - - a rotary one. When the condyle moves anteriorly it does so together with the disk, which glides upon the upper articular surface. In our sections the disk appears to be attached to the medial and lateral portions of the condyle. (Fig. 4 (D) and(E)) and not on the anterior or posterior portion (Fig. 2). It should also be noted in Fig. 4 that the nature of the tissues within and near the attached areas are of different structure on either side.

Discussion of Some of the Elements of the Synovial Fluid of the Joint.

There is not too much known about the synovial fluid. While some investigators have analyzed the quantity of synovial fluid and some of the chemical constituents such as nitrogen content, mucin content, etc. there appears to be no unanimity of opinion. Synovial fluid should have a slightly different composition in each joint in the body and at various times, depending upon the activity, if this fluid behaves like other elements in the human body. We have not come across any analysis of the synovial fluid of the temporo-mandibular joint of a human being. As a matter of fact very little work has been done in a histological sense on this joint.

What are the Functions of the Synovial Fluid?

For one thing it should lubricate the joint, otherwise the wear upon the contacting tissues would be too great for them in spite of the fact that these tissues are particularly tough in character. Certainly there does not appear to be an adequate blood supply in the disk and upon the articulating surface to

bring elements of repair in sufficient supply to offset the amount of wear in an active joint. In the articular areas the tissues appear to be avascular. It therefore follows that there must be a lubricating material in the fluid. The viscosity of the lubricating elements of the fluid would therefore be greater than the other elements. It must first be established that there are some elements in the fluid that are more viscous than others, and if this is established it would be helpful if we could shed some light upon the manner in which these elements gain entrance into the fluid.

In Fig. 5 it will be noticed that a portion of the synovial fluid on the medial side of a frontal section appears to be more viscous than the rest. Fig. 6 is an enlargement of the area containing what we believe to be viscous secretion. This fluid appears to have gathered in a recess of the lower portion under the disk. There also appears to be a villus projecting into the space. In other sections of the same area there appear to be more villi. Thus the viscous portion may have been manufactured by some mechanism in conjunction with the villi or could have come from another portion of the fluid.

The synovial fluid should be the vehicle to bring protective agents to counteract injury and infection. It appears to contain agents that take care of waste products and cellular elements that enter the fluid.

Another important function could be the hydraulic cushioning of the joint to diffuse shock. This is made easier by the contained fluid. Fig. 7(A) shows a gathering of viscous fluid materials in a resting portion of the medial posterior recess of the upper part of the joint.

Evidence of Some Contributing Elements to the Synovial Fluid

(a) Blood Plasma

In Fig. 7 (B) we note a large vessel, under which is a smaller vessel. Although the walls of this vessel do not resemble those of a blood vessel, and although we are considerably mystified by its location, size and apparent influence, we are very much inclined to believe that it is a vessel of a specialized character. We shall discuss this vessel more fully later. Its proximity and apparent communication with the synovial fluid would lead one to believe that there is a transudation of the fluid from the blood vessel to the synovial fluid. A high power view of the area (Fig. 8) shows the vessel to have a very thin endothelial layer of cells and the walls appear to be quite permeable. This is a large vessel and would normally have thick walls. The thinness of the walls would seem to indicate that the vessel is of a specialized character.

Fig. 9(B) shows a blood vessel in the epithelioid portion of the joint, opening directly into the synovial fluid. This would seem to bear out our contention that at least a portion of the synovial fluid receives its material directly from the blood by way of a patent vessel. Occasionally, red blood cells are found in the synovial fluid.

(b) Epithelioid Cells

Fig. 10 shows some of the epithelium-like structures found in the non-articulating portion of the joint. We hesitated at first to call these cells epithelium because of the mesenchymal origin of the tissues. Maximow and Bloom[2] cautiously called them mesenchymal epithelium. When we showed this picture to dentists who have had much experience with epithelium they nearly always thought it was gingival epithelium. H.K. Box stated that the tissue was definitely epithelioid in character. Dr. Arthur Ham, Professor of Histology at the University of Toronto, observed that we could call this tissue epithelium, regardless of its origin. This gives us a much clearer approach in describing the function of this tissue. Fig. 10 (D) shows the secreting, breaking down process of the cells contributing to the content of the synovial fluid. Fig. 11 (B) shows a high power view of a mass of degenerating epithelial cells breaking away from the main body.

Like all tissue where secretions take place, this part of the synovial membrane is highly vascular.

Kling[3] reports secreting cells in the synovial membrane. He argues at great length that the synovial membrane although of mesenchymal origin does secrete. He states that those who hold the view that tissue of that origin cannot secrete are antiquated. He goes on to illustrate and describe secretion. His pictures and description led Davies[4] to believe that what Klind called secretory cells may be identified as mast cells.

In fact Davies does not agree that there are special secretory areas. Our own investigators seem to prove conclusively that there are not only secretory areas but an organized, specialized mechanism involved with this secretion. Perhaps this mechanism is more obvious in the extremely active mandibular joint than in other joints.

Davies seems to agree with Vaubel (1933) that mucin is derived from the connective tissue. He also believes that villi are more concerned with the transfer of metabolites and products of attrition into and out of joints rather than with the production of mucin. He would perhaps alter this view could he see some of our sections.

(c) Fibro-cartilaginous tissue Contribution

This tissue cannot be termed a secretory tissue. It may, however, contribute its ordinary products of wear into the synovial fluid. Occasionally some tissue is seen breaking away, but not enough to seem important. Generally speaking, secretory tissues are highly vascular. This tissue is avascular in contrast to the secreting epithelial tissue.

(d) Hyaluronic Acid, Fats and Proteins

Dr. W. Robert Harris of the Department of Anatomy, University of Toronto, in a pamphlet presented at the University called "Inter-cellular Substances", discusses hyaluronic acid and mentions that it has been discovered in the synovial fluid. This substance is a mucopolysaccharide. There are two types which are distinguished from each other by the fact that one of them, hyalurono-sulphate, contains sulphuric acid, the other is called hyaluronic acid. The mucopolysaccharides include materials which were formerly known as mucins and mucoids, in the glycoprotein group. The polysaccharides are highly polymerized and contain hexosamine as one component. This high polymerization gives it its jelly-like consistency. It responds to the usual test for mucin, the addition of dilute acetic acid forming the clot.

Wells[5] says that there are two chief sources of mucin:- (1) As a product of epithelial cell secretion, and (2) from interstices of connective tissue, especially tendons. This fits into our picture of degenerating cells, their inter-cellular substance, and their intra-cellular substance. It is Davies'[6] belief that there are viscous elements in the synovial fluid, other than those we have mentioned.

Podkaminsky[7] states that there are a number of ferments found in synovial fluid. He mentions amylase, lipase and protease. This would suggest that there are enzymes which digest sugars, fats and proteins. Hyaluronidase in some form is possibly present in the synovial fluid to take care of the mucopolysaccharides. The close proximity of fat to the fluid, as evidenced in our sections, makes one suspicious that lipase is there for that purpose. Could one of the viscous components, suspected by Davies, be fat? We have no difficulty in guessing why protease would be present, by the very nature of the cells.

A Specialized Blood Vessel?

In sagittal sections of the upper posterior medial portion of the joint we have noticed a specialized vessel. (Fig. 12 (A)) Since we have seen this vessel in sections from several rats and each time in the same area, we believe that this vessel is one that is associated with the function of the area. As we have already mentioned, this vessel does not resemble the regular vessels supplying an area. It is much larger than seems to be necessary. It almost wholly occupies the papilla-like structure in the posterior superior portion of the joint which seems to be specially designed for that purpose. The fact that it is almost devoid of blood cells in all our sections of this area, would make one suspicious that hemolysis had taken place. As Dr. Ham pointed out to us, this condition might be due to other causes such as poor fixing or the gravitation of blood cells into other areas. It is our intention to repeat our sectioning several times to eliminate this element of doubt. We are therefore not emphasizing hemolysis at this stage but are merely making a note of its possible presence. Of course the absence of blood cells may be due to causes other than hemolysis.

Although we have done several sagittal sections, we have done only one frontal section up to this writing. Thus the description of our findings are, for the time being, limited until we confirm them by doing other sections.

The frontal or transverse vertical view permits one to study this vessel from a greater vantage point. We now locate the vessel more accurately. It lies quite close to the cranial bone. The first frontal section we observed (Fig.13) was at a junction point between an upper and lower branch. An unfortunate shift in our block prevented us from accurately carrying out our plan of cutting serial sections. We were, nevertheless, able to follow the vessel fairly closely. All future sections will be cut serially and in three planes which should give us a complete perspective.

It may be noted that some blood cells are gathered in the lower part of both the upper and lower branches. The staining of the plasma in the upper vessel is darker than that of the lower one. This is shown in all subsequent sections. Progressive sections towards the anterior Figs. 14, 15 and 16 show the lower vessel fading out into what appears to be a blind end. Towards the posterior, the vessel which supplies what we may call the villus area disappears and we come upon the regular blood vessel from which it evidently originates. Is this the vessel which corresponds to the superficial temporal branch of the external carotid artery which supplies the temporo-mandibular joint in humans? Fig. 17.

Let us study this vessel more minutely, noting in particular the character of its walls which seem to be of a specialized nature to permit either an interchange of fluids or a transudation. Fig. 18 (A) shows a break in the vessel wall resembling a budding and with a consequent loss of plasma into the villus area above. A group of similar thin-walled sinusoidal vessels may be noted in this area. Some of these contain a large number of blood cells. Fig. 19(A) shows a small vessel leading out from the top vessel. A few blood cells may be noted in this vessel. Fig. 20 (A) shows a break in the wall of the upper vessel, while B shows the break in the wall of a vessel making a downward turn. Figs. 21(A) and (B) also show breaks in the upper vessel. Fig. 22(A) shows villi-like metaplasia of the lining cells of the lower vessel. This seems to indicate the specialized character of the vessel and the possibility that chemicals of a specialized nature are being made within the vessel. Fig. 23 (A and B) show two breaks in the lining endothelium opening into the villus area of the lower vessel. (C) is one of the villi-like projections. Is this condition not a rather rare one? What significance shall we attach to it? It might be secretory.

Mast Cells

While studying the sections we have found that mast cells stain blue in areas where functional activity is greater and stain red in areas of rest. We used eosin-hematoxylin stain. We attribute this phenomenon to the fact that the pH is predominantly acid in functioning areas. Lillie's Histo-pathologic Textbook states that, with azure-eosin stain, mast cell granules retain their blue colour at a lower pH level than most other elements.

To us the significance is that the pH of an entire area is affected by the function, and other constituents of the area are correspondingly affected.

Conclusions and Summary

It is our opinion that certain facts have been established that are of importance. Some of these have not been confirmed by repetition. This should be done. Nevertheless, if the Council considers our findings important, we believe that the material to this point of the report may be published. Our serial sections which will be done after this will occupy much room and would perhaps be shown to better advantage in a subsequent report.

As far as we are aware there has up to now been no reference to secretions and secreting cells in the temporo-mandibular joint. These facts alone should be published in a separate report.

In summing up we should like to point out that:-

(1) There are epithelial cells in the synovial lining.

(2) There are secretions by cellular elements into the synovial fluid.

(3) There are elements in the synovial fluid that are more viscous than the main body of fluid.

(4) Blood vessels empty directly into the synovial fluid.

(5) There is a specialized vessel evidently concerned with the chemistry of the squamoso-mandibular joint of the rat.

(6) This vessel has structures unlike that of an ordinary blood vessel.

(7) It is constant in its location and relationship to the joint.

(8) Mast cells stain blue in areas of function, which are acid and stain pink in non-functioning, alkaline areas.

APPENDIX TO REPORT

Some theorizing about our findings

It is sometimes well to theorize. Some attempts at logical explanations frequently lead to avenues where unsuspected truths lurk. It would detract from the importance of this work if some of our theories are proved to be incorrect. We are therefore limiting the main body of this report to our findings with perhaps a little speculation here or there but, in the main, fairly obvious histological and anatomical observations.

In this last part of our report we shall take the liberty of indulging in some theories. We hope to be able to obtain experimental evidence of the truth of some of these speculations.

What happens to the degenerating mass of cells as they enter into the synovial fluid? It is obvious from our sections that there are few epithelial cells, degenerated or otherwise left for any great length of time in the synovial fluid. What is the mechanism? Is it enzyme activity? Are the enzymes manufactured locally by autolysis, are they carried in by the blood? Has function any bearing upon the chemistry of the part? We believe that it has.

PH Variations of the Area

We have already observed that intercellular substances in the tissues surrounding the synovial fluid are apparently affected. We also believe that the fluid substance itself is undergoing chemical and physical changes. Something of a chemical nature therefore is apparently affecting the mucopolysaccharides. This is most likely brought about by enzyme activity.

There is no apparent lysis in the small vessels and certain larger vessels surrounding the area, yet in most of the area immediately surrounding the fluid there are lytic changes in the vessels. We hesitate to use the term hemolysis yet there is a chemical activity that affects most of the blood cells.

The changes could be brought about by alterations of pH. Our observations on mast cells would seem to indicate that the pH is on the acid side in areas of muscular or glandular activity. Mathews[8] claim substantiates experimentally that the contraction of muscles produces acid.

Lowered pH could therefore be due in part to activity. Paradoxically it could also be due to a stasis in a blood vessel. This specialized vessel which is being discussed seems to have several blind endings indicating a showing up of the rate of flow of the plasma. This could cause a localized anoxia which will in turn cause a lowered pH. Mathews[9] states that "acids are particularly prone to set free autolytic enzymes of cells." This is also a factor in an altered pH.

Enzyme affects upon the Walls of the Vessel Itself

As has been noted, the walls of the vessel are not like ordinary blood vessels of that size. The walls as they appear in our illustrations of sections display histological characteristics indicating enzymic activity of an intercellular liquifying nature. There seems to be a loss of all the supporting tissue of the walls. There is even an absence of endothelial lining in many areas. This would permit a transudation of the plasma into the surrounding tissue. The peculiar villi-like structures in the lower vessel (Fig. 22) would encourage the belief that some local secretion is present thereby contributing to the enzyme activity.

Autolysis

We believe that autolysis plays an important role in the chemical changes. When the cells themselves are broken down, enzymes are released which then make possible the completion of the dissolution of cells themselves. Low pH seems necessary for autolytic action. Mathews[10] states that "Autolytic enzymes of cells are easily checked by maintenance of neutral or faintly alkaline reaction."

Amylase, Hyaluronidase and PH

It is an established fact that the breaking down of substances of a mucopolysaccharide character is brought about by enzyme activity. In the past some of these enzymes were called amylase and now most of them are referred to as hyaluronidase. Perhaps it is the differences in the pH alone that caused the differences in enzyme activity. Davies[11] in 1943 was able to extract mucin without removing cellular elements and connective tissue fibre by incubating sectional tissue which had been stained with toluidine blue. This was done with a concentrated solution of hyaluronic acid of pH 4.6. This gives us the clue that perhaps there are not many types of hyaluronidase but that there is a different activity in different pH's. We plan to experiment with this during the coming year.

Fat

Fat is a characteristic element of most joints. There is often a reference to "fat pads". This designation implies its function to be, in part at least, a physical one. It is inferred that there is a cushioning effect on joint movements. In the case of the mandibular joint, however, the distribution of the fat cells fails to indicate any such physical role. As may be seen in the sections they are not present in or associated with fibro-cartillagenous tissue where obvious functional stresses occur. It is clear then that some other than a purely physical role must be attributed to this fat accumulation.

Fat occurs in the body in areas of low metabolic activity. The presence of lipase in the synovial fluid may indicate that there is a relationship between the fat and the fluid content. It seems possible that the glycolytic action in the lining cells have a relation to the accumulation of fat.

There may be a relationship between the mucopolysaccharide content of the area, the lowered pH due to function, the anoxia and synthesis into fat. The function of a joint may be the direct cause, therefore, of fat storage beds.

The writer is extremely grateful to Mr. Frank Fenton for his kind assistance. His sections were extremely well prepared and some of his observations were clever indeed. To Mr. Fenton must go the credit of observing difference in colour of most cells in different areas.

C.H. Moses, D.D.S., B. Sc. (Dent.)
Research Assistant

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(10) Idem. 107.

(11) The staining reactions of normal synovial membrane with special reference to the origin of synovial mucin, by D.V. Davies. J. Anat. 77. Jan., 1943.

PHOTOGRAPHIC LEGEND

Fig. 1 A. Incisor; B. Condyle; C. Posterior teeth. Forces exerted at the incisal edge of the incisor tooth are transmitted throughout the mandible. Sagittal View of the Joint.

Fig. 2 A. Squamosa; B. Fibro-cartilaginous articular surface; C. Villi in posterior superior part of the joint; D. Fibro-cartilaginous meniscus or disk; E. Muscle pulling condyle; F. anteriorly; G. Rows of fat cells.

Fig. 3 High power view of a portion of the articular area. This part is avascular and fibro-cartilaginous. A. Articular surfaces; B. Fibro-cartilaginous meniscus or disk; C. Synovial fluid; D. Condyle.

Fig. 4 Frontal view of the joint. A. Squamosal bone; B. Articular surface; C. Disk; D. Medial attachment; E. Lateral attachment; F. Condyle; G. Synovial Fluid.

Fig. 5 Frontal View. A. Synovial fluid; B. Collection of more viscous material in medial portion of the underneath part of the joint.

Fig. 6 A. High power view of viscous material of the synovial fluid.

Fig. 7 A. Viscous material in synovial fluid of upper part of the joint; B. Specialized blood vessel; C. Lower branch of the same vessel staining lighter; D. Fat cells; E. Condyle.

Fig. 8 Higher magnification of Fig. 7 showing A. Viscous material in synovial fluid; B. Specialized blood vessel.

Fig. 9 Epithelial portion of synovial membrane. A. Duct-like fold of villi; B. Blood vessel opening into the synovial space; C. Fat cell; D. Epithelioid cells contributing globules; E. Synovial fluid.

Fig. 10 Synovial epithelium. A. Epithelium cell layer; B. Blood vessel; C. Synovial fluid; D. Breaking down cellular material.

Fig. 11 High power view of a mass of degenerating cells. A. Synovial fluid; B. Degenerating surface tissue en masse; C. Epithelial surface cells of Villi.

Fig. 12 Sagittal section, medial cut. A. Specialized vessel almost completely occupying a papilla-like body in posterior part of the joint; B. Disk; C. Condyle.

Fig. 13 Frontal view of specialized vessel at the point where a lower branch joins. A. Upper vessel; B. Lower vessel with lighter staining properties; C. Junction of fluid of upper and lower vessels with line of demarcation between the two fluids; D. Condyle.

Fig. 14 Upper and lower vessels separating but showing different staining qualities. This section is anterior to Fig. 13. A. Upper vessel; B. Lower vessel.

Fig. 15 Section anterior to Fig. 14. showing lower branch fading out. A. Upper Vessel; B. Lower Vessel; C. Fat cells.

Fig. 16 A. Upper vessel; B. Lower vessel fading out into a blind end.

Fig. 17 A. Large vessel in a posterior section. This vessel leads into the specialized vessel.

Fig. 18 A. Break in Vessel Wall; B. Number of vessels with similar wall structures containing red blood cells.

Fig. 19 A. Small vessel leading out of upper vessel.

Fig. 20 A. Break in Wall of Upper vessel; B. Break of vessel wall making a turn.

Fig. 21 A. and B. Breaks in lining of upper vessel.

Fig. 22 A. Villi-like metaplasia of lining cells in lower vessel.

Fig. 23 A. and B. Breaks in lining endothelium opening into villus area.

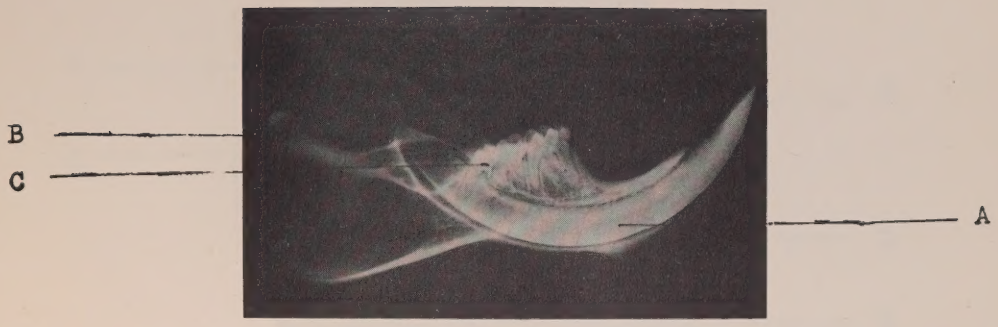
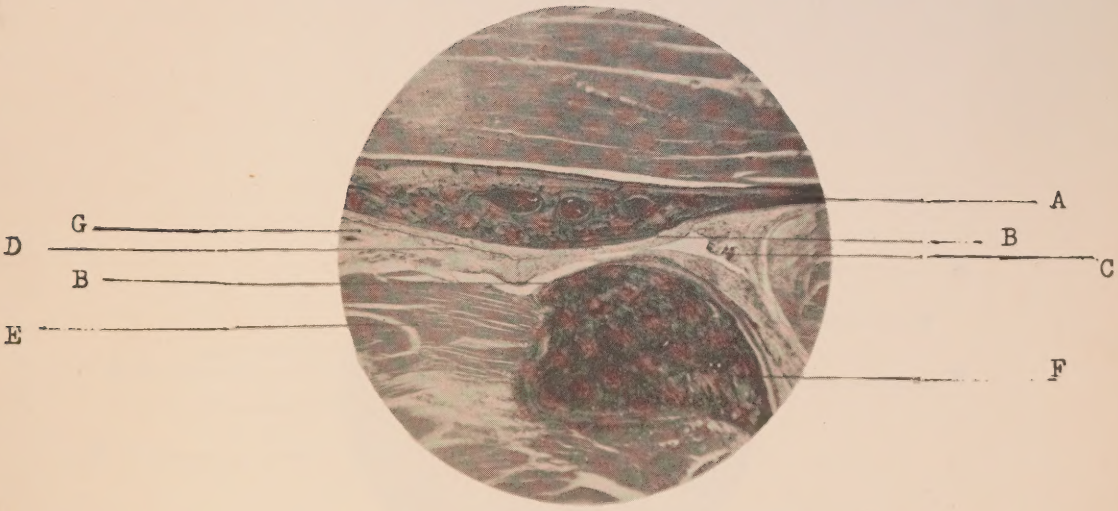


Fig.1



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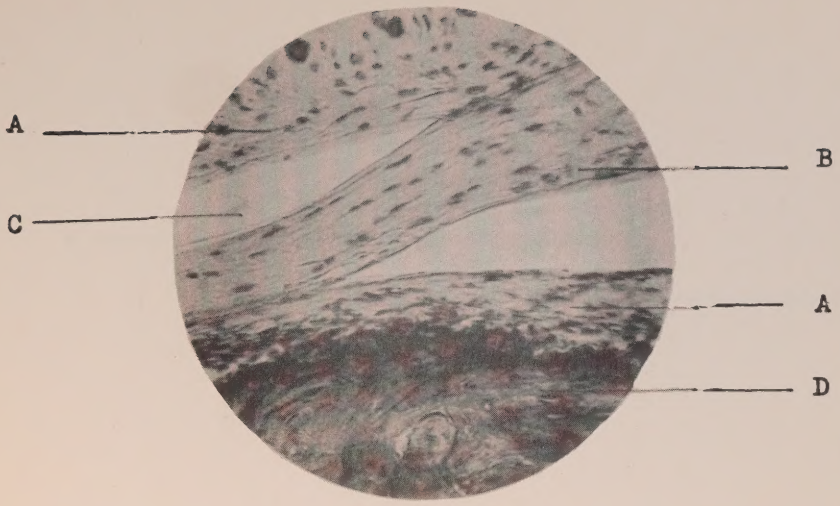

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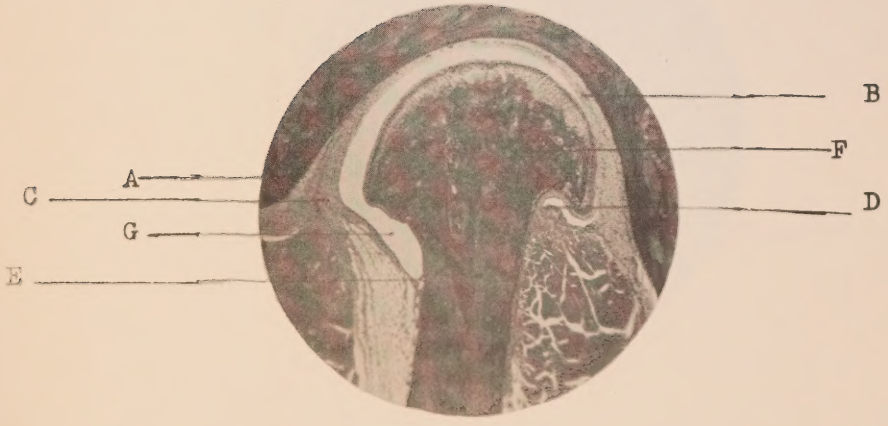
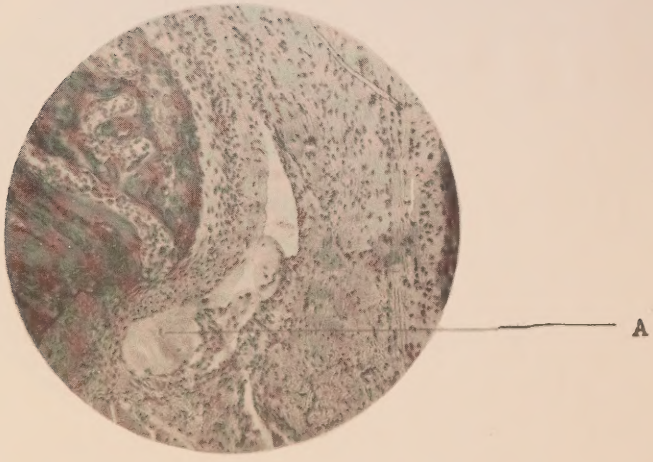


Fig.4

Fig.5



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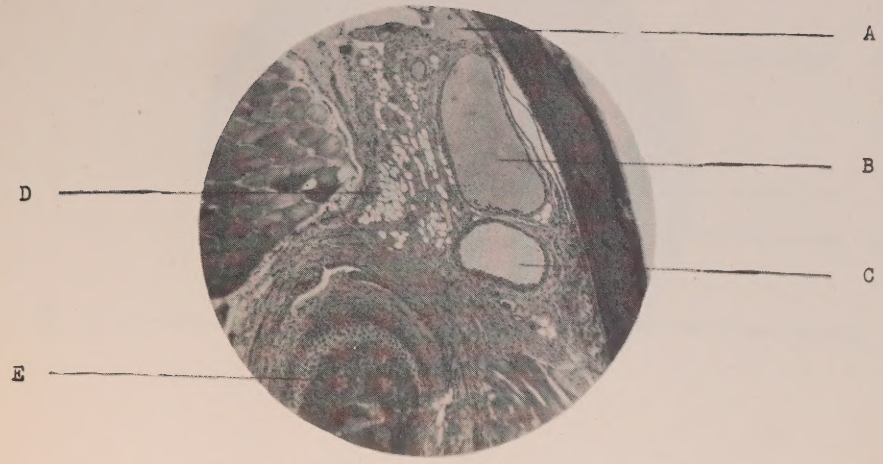

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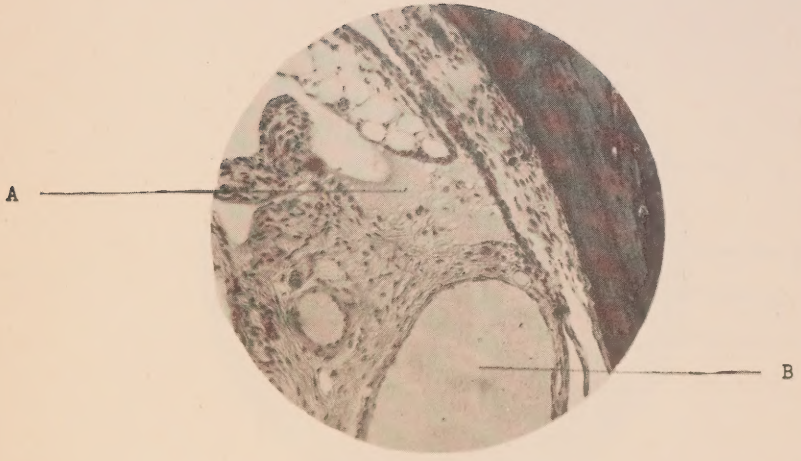

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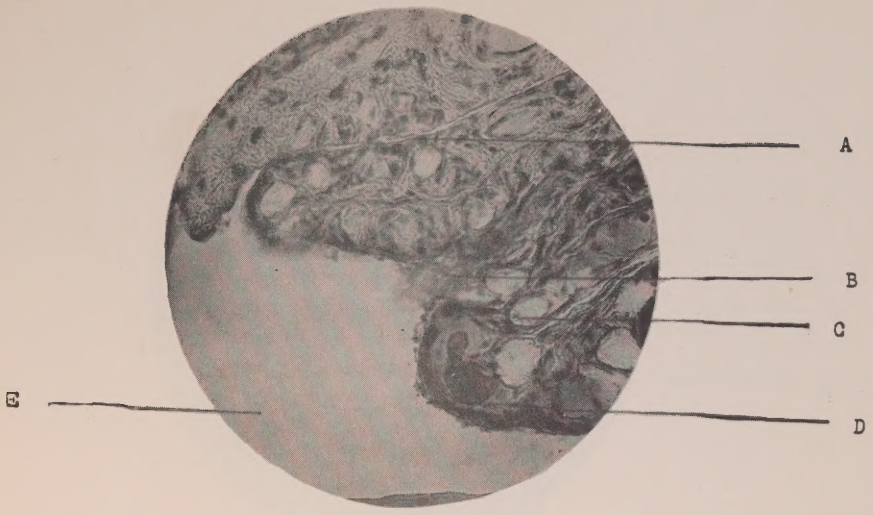

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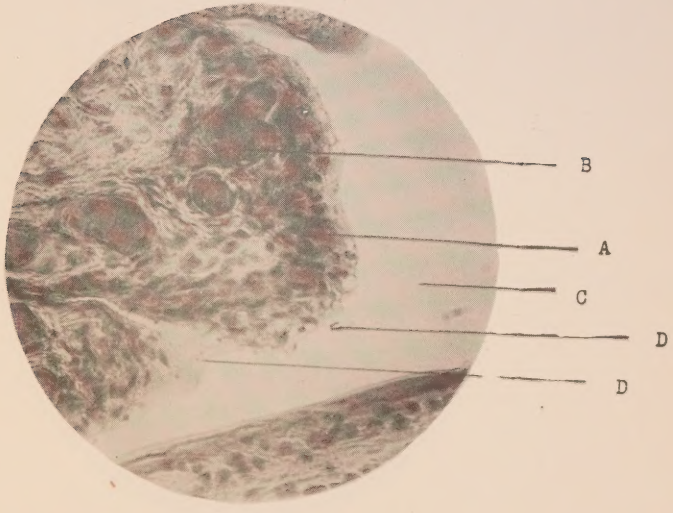

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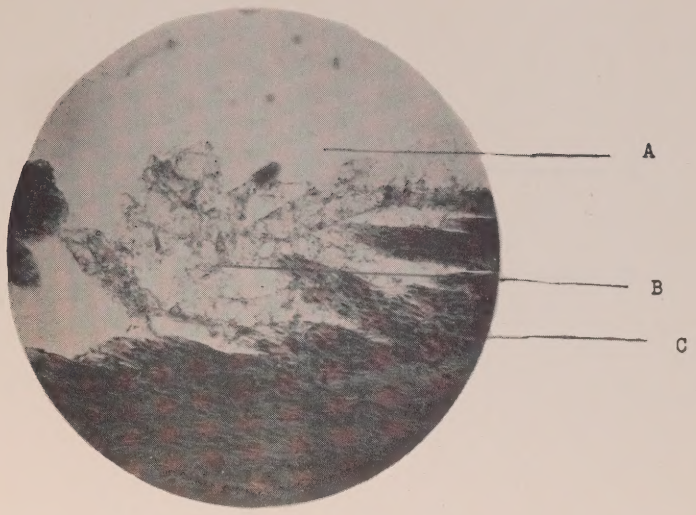

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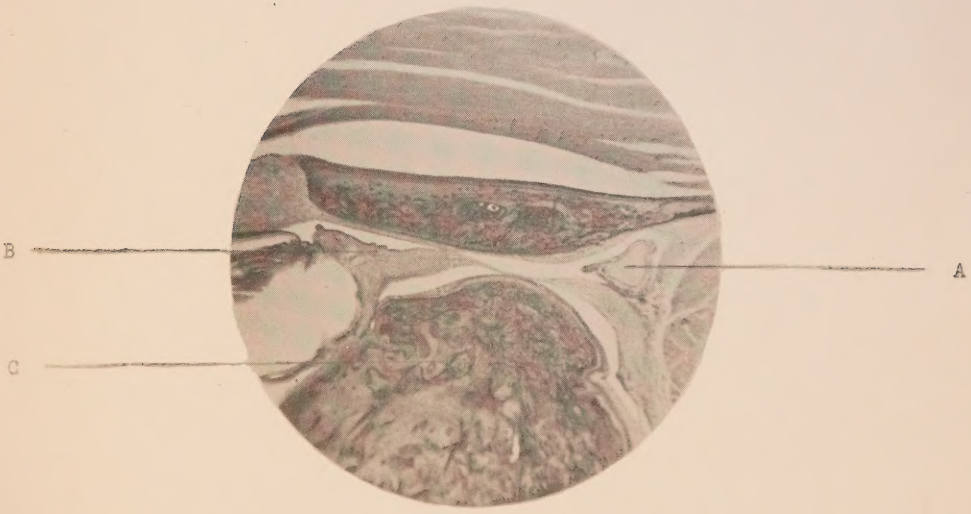

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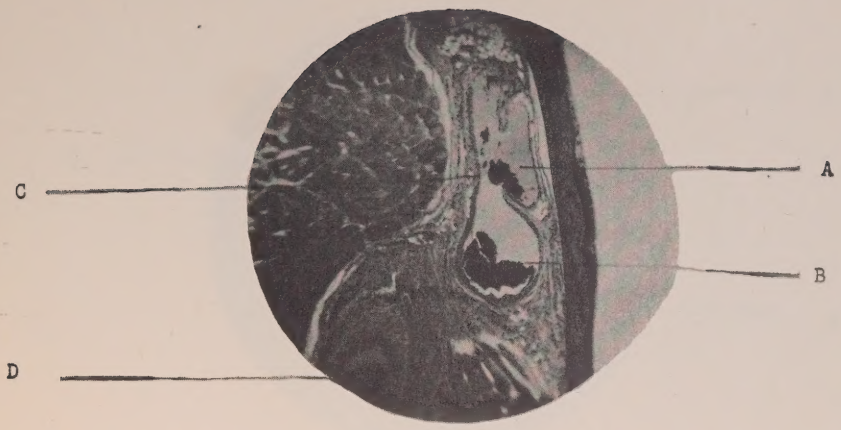

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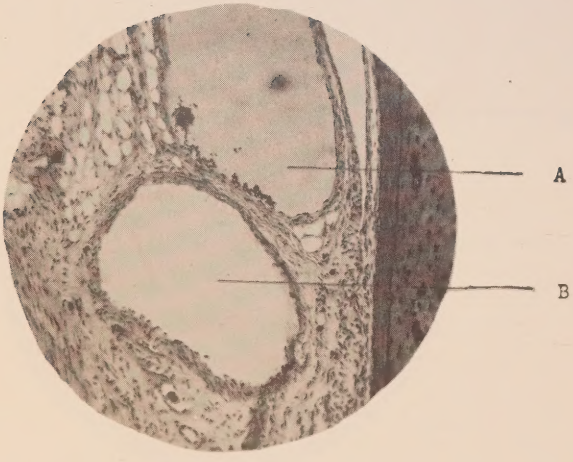

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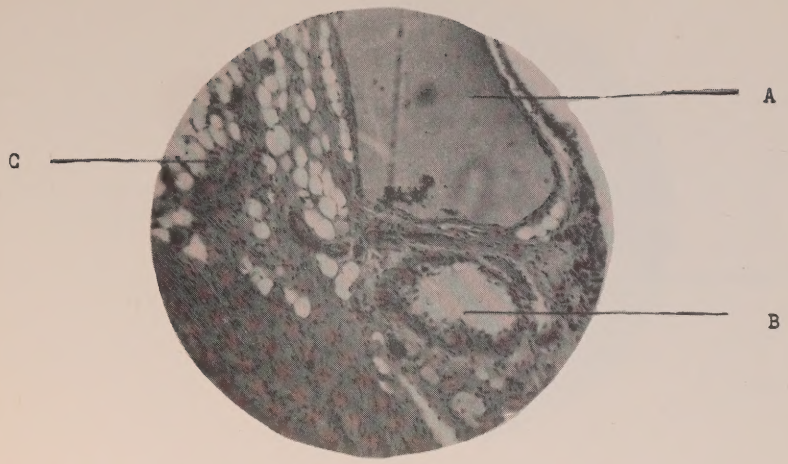

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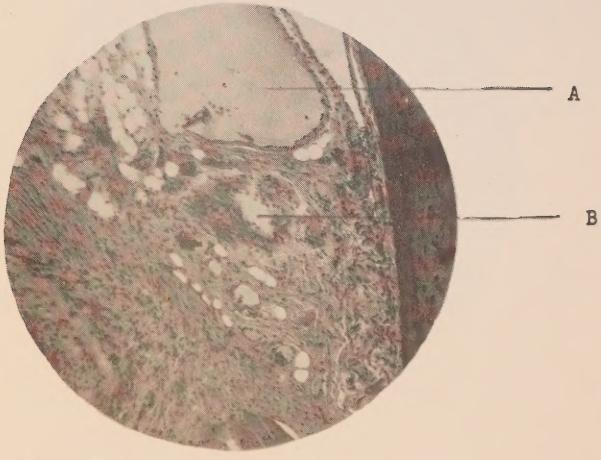

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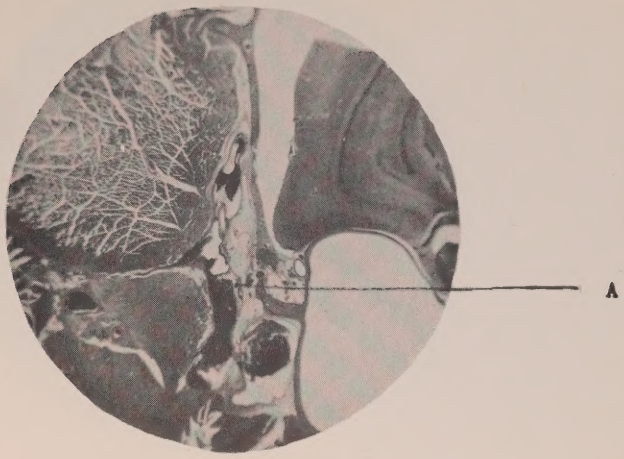

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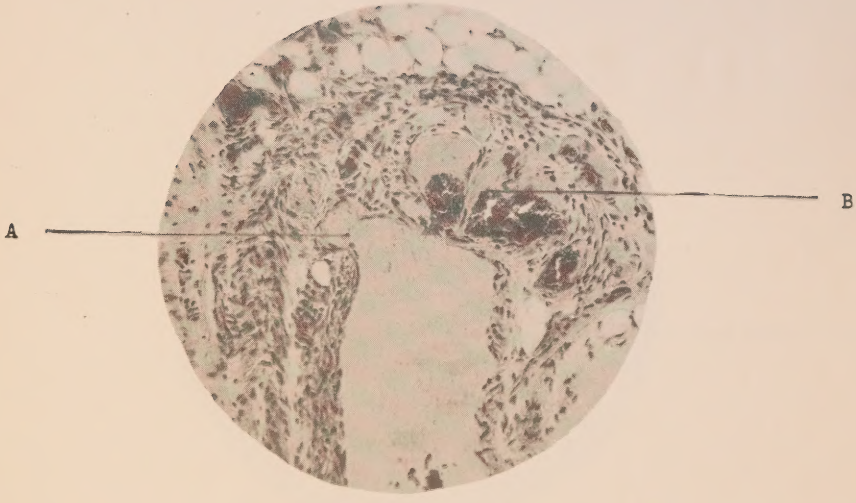

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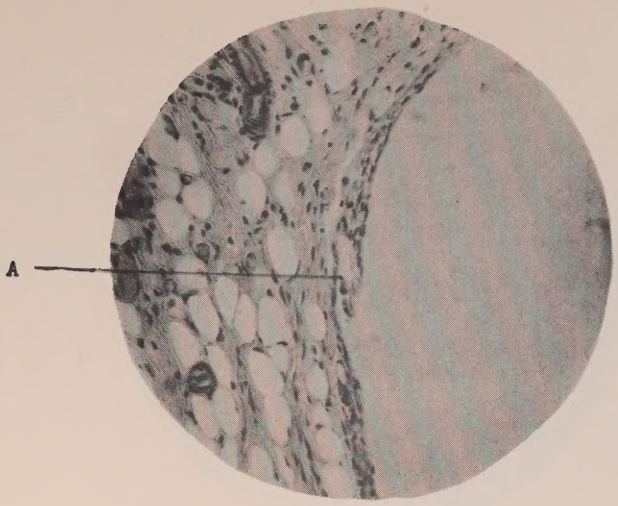

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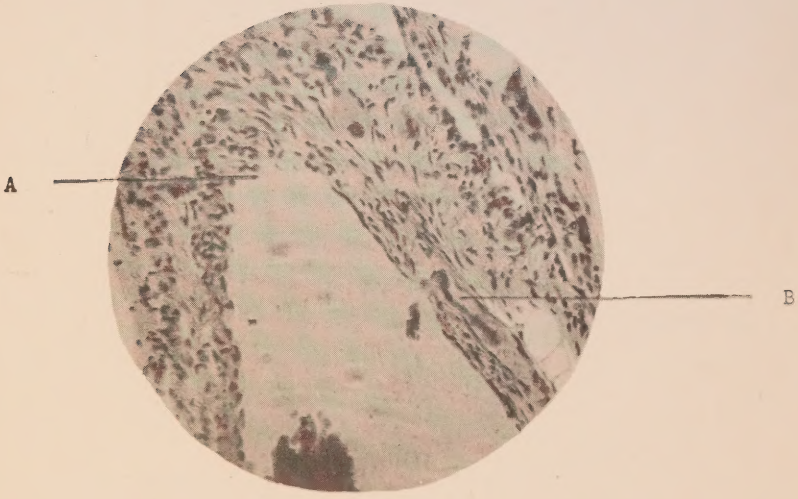

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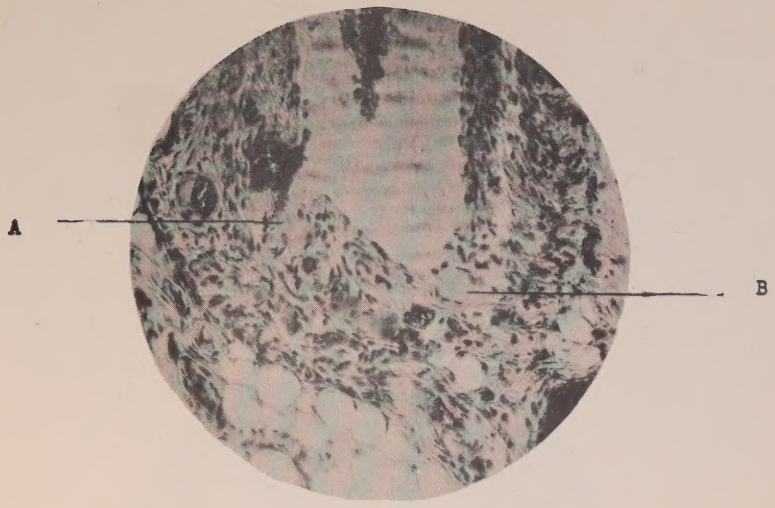

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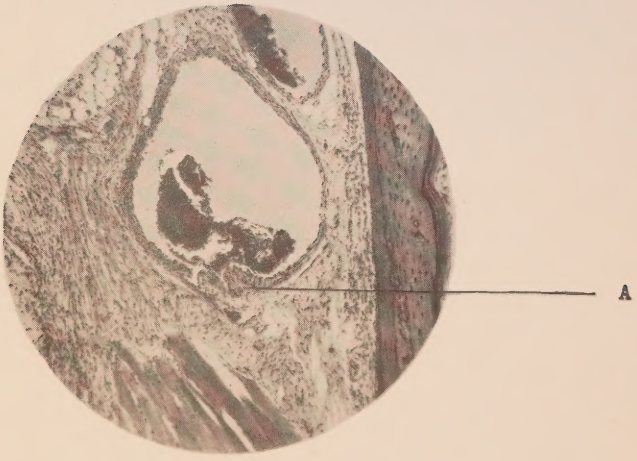

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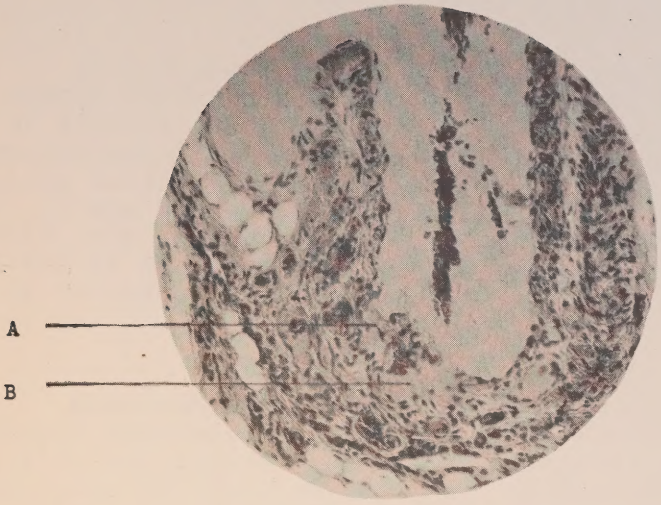

Fig.23

APPENDIX "N"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: A study of alveolar oxygen tension and blood oxygen content during nitrous oxide anaesthesia.

Authors: R.J.S. Tickle and G.H.W. Lucas
Department of Pharmacology,
University of Toronto.

Grant No.: DR 2 Amount of Grant: $1450.

Purpose

It had previously been pointed out that the Beckman oxygen analyser was unsatisfactory for analysing samples of expired air collected during nitrous oxide-oxygen anaesthesia, since it was not possible to collect a sufficient volume of gas to ensure a constant and accurate reading. It was therefore necessary to employ another method of analysis, one in which smaller samples of gas could be analysed and at the same time the carbon dioxide content of the gas be estimated.

Scope

Experimentation with the Fry gas analyser showed that accurate analyses could be made on 1 cc. or less of gas and that with the use of suitable solutions a technique could be standardised for the determination of the oxygen and carbon dioxide content of the sample. The nitrous oxide was estimated by difference. At present gas samples of expired air are being obtained and analysed from patients during dental anaesthesia and the oxygen and carbon dioxide percentage thus determined. Control samples of gas from the anaesthetic machine are also being analysed to determine the accuracy of the dial setting and the oxygen percentage of the gas mixture.

Conclusions

1. A satisfactory technique has been found which will determine with sufficient accuracy the oxygen and carbon dioxide percentage of small samples of gas mixtures.

2. The analyses of samples taken during anaesthesia so far indicate some discrepancy between the oxygen percentage dial settings, the calculated oxygen percentage delivery and the oxygen percentage of the expired air. In almost all cases the oxygen percentage of the expired air is in excess of the oxygen percentage dial settings.

Date: February, 1949.

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Date: February, 1944.

APPENDIX "O"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March 1949

Subject: A comparison of ten local anaesthetics

Grantee: Dr. J.K.W. Ferguson (for Dr. E.A. Sellers)

Project No.:DR 19 Amount of Grant: $1575.

SUMMARY OF WORK

Ten local anaesthetics are being compared in two characteristics, (1) effectiveness in the production of nerve block, (2) toxicity to tissues at the site of injection. For the assessment of effectiveness in producing nerve block, use is made of retro-bulbar block in guinea pigs. Two-tenths of a cc. of anaesthetic are injected behind the eyeball and the course of the anaesthesia is followed by observing the dilatation of the pupil, loss of light reflex, and loss of corneal sensitivity. Tissue toxicity is assessed by observing the results of intradermal injections of various strengths of the anaesthetics into the skin of guinea pigs. The retro-bulbar block seems to be superior to any method devised as yet for the quantitative study of conduction block under conditions simulating actual use.

Date: February 1, 1949. Signature J.K.W.Ferguson

APPENDIX "O"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

MARCH 1949

Subject: A comparison of ten local anaesthetics.

Authors: J.F. Aikenhead and J.K.W. Ferguson,
Department of Pharmacology,
University of Toronto.

Project No.: DR 19 Amount of Grant:$1575.

A full report on this project was submitted in October 1948 in the form of a paper for publication, entitled A Comparison of Nine Local Anaesthetics, by Hamilton, Westfall and Ferguson. This paper has since appeared in the Journal of Pharmacology. Consequently the following report will deal only with developments since the previous report. A tenth local anaesthetic has been added to those under investigation. The list now consists of procaine, metycaine, monocaine, naphthocaine, butacaine, octacaine, cocaine, pontocaine, nupercaine, and holocaine. The work in progress is concerned with comparing these ten local anaesthetics as to effectiveness in the production of nerve block anaesthesia and also in their toxicity to tissues at the site of injection. The comparison of tissue toxicity is being made by a method described in the previous report which makes use of injection of various concentrations of the anaesthetics intra-dermally into the skin of guinea pigs and observing the magnitude of the erythematous reaction.

The comparison of local anaesthetics for effectiveness in nerve block has always presented problems. A method which gave the most consistent results in the past was that which made use of the isolated frog nerve. Such a method, however, was not directly comparable to the conditions under which nerve block anaesthesia is performed. Another method of comparison made use of injections around the sciatic nerve of the guinea pig. Results by this method were, however, very erratic, presumably because it was impossible to see exactly where the local anaesthetic was being injected and also because variations in vascularity around the nerve caused removal of the anaesthetic at different rates.

In our hands the block of the sciatic nerve in the guinea pig proved to be quite impractical. All too often for no obvious reason no block seemed to be produced at all. One reason for irregular results is that the manifestation of successful block is merely partial paralysis of one hind limb and it is hard to make observations of this effect. We have, accordingly, tried another method, namely

a retro-bulbar block. This involves injecting approximately two-tenths of a cc. of local anaesthetic behind the eyeball of the guinea pig so that the ciliary nerves (and probably the optic nerve) are blocked. The depth and duration of anaesthesia can be observed by three criteria: (1) dilatation of the pupil; (2) loss of light reflex; (3) loss of corneal sensitivity. We feel that this method of observing conduction anaesthesia is a great improvement on any used heretofore. However, it is noticeable that results are not nearly as uniform as with anaesthsia with intradermal injection. This is probably due not only to lack of visual control at the site of injection but also due to variable vascularity in the field of injection. Perhaps these sources of error can never be entirely eliminated from experiments on conduction block. It seems important, however, that assessment of local anaesthetics for effectiveness in conduction block should be done by means of conduction blocks rather than by intradermal injection, because the conditions of active circulation around the nerve may modify the characteristics of different anaesthetics to a different degree. The large element of variation in these experiments on conduction block will make it necessary to do many experiments before a basis of comparison can be established between the anaesthetics under study. So far it appears that the relative potency of the various anaesthetics for conduction block is only roughly shown by intradermal injection.

J.K.W. Ferguson
Signature.

APPENDIX "P"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March 1949

Subject: A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of the dental arches.

Grantee: Norma Ford Walker

Project No.:DR 15 Amount of Grant: $3,000.

SUMMARY OF WORK

To date 3 series of casts have been made and measured for one hundred and eleven children and 4 series for twenty-eight children. The interest and co-operation of both parents and children have been so well sustained that only two children have dropped from the study and these two because they moved away from Toronto. It is planned that a total of 6 impressions will be taken for each child.

The study has involved the long and slow collecting of a considerable body of data before any final analysis could be begun. Although records will continue to come in, it is planned for one set of data to" close the books" in April and at that time to make the final calculations for the mean eruption times for each deciduous tooth, separately and as homologous pairs, and for sexes separated and sexes combined. (This data can be compared with that of the Fells Research Institute who independently undertook the same problem). Preliminary calculations will also be made for the mean widths of the dental arches at varying ages, sexes separated and combined (for comparison with the data of Lewis and Lehman '29 and others).

These two sets of data are basic to the whole study. When they have been analysed, the final comparisons of the eruption pattern of the deciduous teeth and the rates of growth of the dental arches can be made. This study to be completed by March 1950.

As an illustration of the practical application of the value of such records, we were recently able to supply on request to a pedodontist data regarding an adopted child, who had both a "mixed" pattern of deciduous eruption and also dental arches whose widths in three series of casts fell far below the standard deviations.

Date: February 1949. Norma Ford Walker
Signature

APPENDIX "Q"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Experimental Artificial Production of Dental Caries in Vitro

Grantee: H.K. Box

Project No.: DR 18 Amount of Grant: $1,620.00

SUMMARY OF WORK

Scope: The experimental work was carried out on human, hog and cattle teeth and under three phases or combination of phases:

(a) Acid Phase
(b) Enzyme Phase
(c) Acid-Enzyme Phase

A Acid Phase

1. Human teeth were subjected to the action of .1% solutions of lactic acid and hydrochloric acid (approx. pH 4.5) for two months.

2. Cattle teeth were subjected to the action of .5% solution of lactic acid (approx. pH 4.5) for two months.

The general observations on these experiments, except for hog teeth are:

(a) Loss of most of the decalcified enamel over the "window"
(b) Cross-striation in the enamel prisms
(c) Destruction of interprismatic substance
(d) Translucency in the enamel

B Enzyme Phase

1. Human teeth were subjected to the action of the following enzymes pepsin, papain, trypsin, amylase, ptyalin, sulfanase, for a period of four to five months.

2. Cattle and hog teeth were placed in pepsin enzyme (20, 30, 40% solutions - approx. pH 4.5) for a period of seventy days.

APPENDIX "G"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1946

Subject: Experimental Artificial Production of Dental Caries in Vitro

Grantee: H.K. Box

Project No.: DR 12 Amount of Grant: $1,620.00

SUMMARY OF WORK

Scope: The experimental work was carried out on human, hog and cattle teeth and under three phases or combination of phases:

(a) Acid Phase
(b) Enzyme Phase
(c) Acid-Enzyme Phase

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1. Human teeth were subjected to the action of the following enzymes pepsin, papain, trypsin, amylase, ptyalin, sulfatase, for a period of four to five months.

2. Cattle and hog teeth were placed in pepsin enzyme (20, 30, 40% solutions - approx. pH 4.5) for a period of seventy days.

The observations on these experiments:-

(a) The results of the experiments on human teeth cannot be recorded at this writing.
(b) Results of experiments on cattle teeth are:

(i) the interprismatic spaces between the enamel rods appeared to be opened up or partly dissolved or washed out
(ii) at the extremity of the affected enamel was a yellowish brown pigmented border which may slowly disappear.
(iii) the dark brownish pigment present in normal cow enamel is removed. This may be removed by the proteolytic activity of the pepsin.

(c) Results of experiments on hog teeth were somewhat varying in that enzyme proteolysis will produce greater destruction of the enamel. A greater degree of pigmentation was present, but enamel structure became slightly disorganized and broken up.

C Acid-Enzyme Phase

1. Human teeth were placed in a mixture of an acid (lactic, phosphoric, pyruvic, malic, formic, tartaric) - 1% solution, pH 4.5 with a 30% solution of pepsin enzyme pH 4.5 for a period of two months and then in a 30% pepsin enzyme solution alone for four months. It was found that the changes produced artificially characteristic of enamel caries are the following:-

(a) Pigmentation - a darkly pigmented(orangey-yellow) band can be seen in advance of the carious lesion
(b) Transverse Striation - these are cross-striae seen on enamel prisms in the artificial carious lesion
(c) Destruction of the interprismatic substance with minute spaces between the enamel rods
(d) Granulation and pigmentation of the enamel prisms
(e) Transparent enamel

The changes produced artificially characteristic of certain changes in the dentin in caries are the following:-

(a) A yellowish-orange pigmentation of the dentin below and at the dento-enamel junction
(b) Dentin shrinkage at the dento-enamel junction
(c) Transparent dentin underneath the zone of yellowish pigmentation

The observations on these experiments:-

(a) The results of the experiments on human teeth cannot be recorded at this writing.

(b) Results of experiments on cattle teeth are:

(i) the interprismatic spaces between the enamel rods appeared to be opened up or partly dissolved or washed out

(ii) at the extremity of the affected enamel was a yellowish brown pigmented border which may slowly disappear.

(iii) the dark brownish pigment present in normal cow enamel is removed. This may be removed by the proteolytic activity of the pepsin.

(c) Results of experiments on dog teeth were somewhat varying in that enzyme proteolysis will produce greater destruction of the enamel. A greater degree of pigmentation was present, but enamel structure became slightly disorganized and broken up.

C Acid-Enzyme Phase

1. Human teeth were placed in a mixture of an acid (lactic, phosphoric, pyruvic, malic, formic, tartaric) - 1% solution, pH 4.5 with a 30% solution of pepsin enzyme pH 4.5 for a period of two months and then in a 30% pepsin enzyme solution alone for four months. It was found that the changes produced artificially characteristic of enamel caries are the following:-

(a) Pigmentation - a darkly pigmented(orange-yellow) band can be seen in advance of the carious lesion

(b) Transverse Striation - these are crossstriae seen on enamel prisms in the artificial carious lesion

(c) Destruction of the interprismatic substance with minute spaces between the enamel rods

(d) Granulation and pigmentation of the enamel prisms

(e) Transparent enamel

The changes produced artificially characteristic of certain changes in the dentin in caries are the following:-

(a) A yellowish-orange pigmentation of the dentin below and at the dento-enamel junction

(b) Dentin shrinkage at the dento-enamel junction

(c) Transparent dentin underneath the zone of yellowish pigmentation

2. Cow and Hog teeth were subjected to the same experimentation using only lactic acid and pepsin as the chemical agents in the experiment.

The results proved to be somewhat similar to those obtained in human teeth except that there were no changes produced in cow dentin, and to some extent, changes characteristic of dentin caries were produced in the dentin of hog teeth. However, characteristics of enamel caries were less pronounced as those produced in human teeth due to less regular arranged enamel structure characteristic of animal teeth as compared to human teeth.

The significant conclusions that can be drawn from the observations of experiments on the phases of caries are threefold.

1. Changes produced by acid action alone lacks many features of the caries picture. The acid attacks the inorganic content of teeth.

2. Proteolytic pepsin enzyme attacks the organic content of teeth and the changes produced characteristic of caries are more pronounced when activated by acid action.

3. A combined acid-enzyme attack produces many of the changes that are produced in a frontal caries process.

(SUMMARY)

APPENDIX "Q"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March, 1949

Subject: Experimental Artificial Production of Dental Caries in Vitro

Grantee: H.K. Box, D.D.S., Ph.D., and R.A. Hugill, D.D.S.

Project No.: DR 18 Amount of Grant: $1,620.00

ANNUAL REPORT

Purpose: The purpose of this project is to produce, if possible, an artificial dental caries lesion in vitro, to meet the microscopical qualifications of the true caries picture. Among the characteristic features of dental caries in ground sections regarded by many observers are the following:

1. Pigmentation - On approximal surfaces, a band of darkly pigmented material is frequently observed on the border of the advancing carious lesion. This band varies in width. This change has been interpreted in different ways, and it has been stated that it does not occur in pulpless teeth and cannot be produced artificially. Also, the involved enamel in some cases shows yellowish and brownish pigmentation in the carious lesion.

2. Transverse Striation - The enamel prisms show marked striae and this is commonly regarded as a result of the action of acids.

3. Destruction of the interprismatic substance with the formation minute spaces between the enamel rods.

4. Granulation and pigmentation of the prisms.

5. Translucent enamel, apparently produced by acid action.

Certain changes in the dentin in caries:

1. Yellowish orange pigmentation of the dentin at the base of the lamellae and in frontal carious lesions, at the dento-enamel junction.

2. Dentin shrinkage at the dento-enamel junction beneath carious lesions in the enamel

3. Translucent dentin underneath zones of yellow pigmentation.

4. Rod-shaped fragments and granules in the dentinal tubules frequently observed just beyond the advancing caries.

Scope: Two processes have been claimed to be fundamental in the production of dental caries, namely -

(1) Acid - decalcification

(2) Enzyme - proteolysis

With this evidence of the nature of the phases of dental caries, a series of experiments were carried out in vitro on extracted teeth in which two active factors believed to be produced by bacteria, i.e. acids and enzymes, were used directly with no oral or other bacteria present.

The experimental work was carried out on human and animal (hog, cattle) teeth under three phases or combination of phases -

1. Acid Phase

2. Enzyme Phase

3. Acid-Enzyme Phase

Experiments Carried Out on Cattle Teeth

A Enzyme Phase:

Lower anterior teeth were completely coated with black compound except for a small "window" on the labial surface. The teeth were placed in 20%, 30% and 40% solutions of pepsin enzyme, pH approximately 4.5. Thymol crystals were added to control or inhibit bacterial activity. The observations were as follows:

1. Observations for 20%, 30%, 40% pepsin enzyme activity were relatively the same.

2. There was very little difference as to the depth of penetration in relation to the concentration or percentage strength of the pepsin enzyme solutions.

3. Before grinding, the exposed window on the labial surface presented a solid, hard, intact surface possessing a dark orangey-brown stain.

4. On rough section, the area below the window showed a marked difference in light opacity to that of normal unaffected enamel. There appeared to be a milkish cup-shaped penetration, three-quarters of the way through the enamel to the dento-enamel junction.

5. On the finished polished section the following observations were made.

   (a) Part of the affected enamel beneath the window would chip away during the grinding and polishing process. The broken pieces were not decomposed or broken down, but were relatively hard.

   (b) The interpresmatic spaces between the enamel rods appeared to be opened up or partly dissolved or washed out (fig. 4,9)

   (c) At the extremity of the affected enamel below the window was a yellowish-brown pigmented border which will slowly disappear over a period of two to three months (fig. 3)

   (d) The affected enamel may or may not contain a light yellowish discoloration (fig. 3, 9 show yellowish discoloration of enamel)

(e) The dark brownish pigment present in the enamel is removed. This may be removed by the proteolytic activity of the pepsin (fig. 3, 9)

(f) There is evidence of slight proteolytic activity beyond the pigmented border in the interpresmatic spaces (fig. 3, 9)

(g) There is no evidence of cross-striation

The possible conclusions are as follows:

1. The pepsin enzyme attacked only the organic matrix of the enamel, thus opening up the interprismatic spaces.

2. The spaces that are microscopically evident may be due to the digestion of the organic enamel sheathes.

3. The activity of the pepsin in spite of its relative acid p^H does not cause or produce any microscopical evidence of decalcification i.e. no cross-striation was present.

B Acid Phase:

Lower anterior teeth were completely covered with black compound except for a small window on the labial surface. The teeth were placed in a .5% solution of lactic acid, p^H 3.5. Thymol crystals were added to control bacterial activity.

The observations were as follows:

1. Before grinding the section, the window on the labial surface of the tooth presented an area of soft milkish-white material which could be readily washed out. A definite cup-shaped depression was formed in the tooth.

2. On grinding, a considerable amount of the tooth structure underlying the window was lost.

3. The decalcified structure remaining at the base of the window when held against the light, possessed a greyish-crystalline transparency or translucency.

4. There was marked evidence of cross-striation, destruction of interprismatic substance and somewhat of a translucency to the enamel (fig. 2)

5. The interod spaces did not appear to be as clearly defined as in sections reacted on by the enzyme. (fig. 2,4).

6. There was no evidence whatsoever of pigmentation.

The possible conclusions are as follows:

1. Acid decalcifies and removes the enamel rods.

2. In partial decalcification, acid produces in the enamel
   (a) cross-striation
   (b) interprismatic destruction
   (c) translucency of the enamel

3. Acids are evidently not responsible for pigmentation.

C Acid-Enzyme Phase

Lower anterior teeth were completely coated with black compound except for a "window" on the labial surface. The teeth were placed in a 30% solution of pepsin enzyme and a 1% solution of lactic acid, pH 3.5. Thymol crystals were added to control bacterial activity.

The observations were as follows:

1. Previous to sectioning the window remained intact, and no depression was produced in the surface of the tooth. However, the surface structure on the window was not as hard as the enamel affected by the acid alone.

2. On grinding, some of the enamel structure below window was lost.

3. The remaining enamel structure at the base of the window produced a combination of microscopical pictures produced by the action of acids and enzymes separately.

4. Cross-striation, (fig. 5, 6, 7) destruction of interprismatic substance (fig. 5, 6, 7, 8) areas of translucency in advance of the grossly affected areas of the enamel, (fig. 5), and a pigmented band- especially at the border of the microscopically apparent destructive process in the enamel, (fig. 8) were produced by the acid and enzyme in combination.

EXPERIMENTS CARRIED OUT ON HOGS' TEETH

A Enzyme-Phase

Anterior teeth were completely coated with black compound except for a small "window" on the labial surface. The teeth were placed in 20%, 30% and 40% solutions of pepsin enzyme, pH 4.5. Thymol crystals were added to control bacterial activity.

The observations were as follows:

1. On the labial surface of the enamel over the window, a cup-shaped depression was produced and the window appeared to be considerably pigmented of an orangey-brown colour.

2. The action of the pepsin in most cases had penetrated through the enamel into the dentin (fig. 10).

3. Some of the enamel structure was lost during the grinding and sectioning of the tooth.

4. The remaining enamel structure was pigmented yellowish orange over the window. The interod spaces were very definitely washed out. (fig. 10).

5. A milkish-grey opacity was apparent in the affected enamel when held against the light.

6. The remaining enamel structure was of a slightly yellowish pigmented discoloration. (fig. 10).

7. The dentinal tubules appeared to be enlarged or swollen in the affected area, although the tubule structure did not appear to be impaired (fig. 10).

8. The affected dentin possessed a slight yellowish pigmentation (fig. 10).

9. No cross-striation of enamel rods was evident.

The possible conclusions and explanations are as follows:

1. Some of the findings on the effects of pepsin enzyme on hogs' teeth are contrary to the findings produced by pepsin enzyme on cattle teeth. For example, the affected enamel in the window remained intact in the sectioned cattle teeth and no depression was produced into the enamel surface, whereas in hogs' teeth a depression was produced in the enamel surface and part of

the enamel structure was lost during grinding and sectioning. This may be explained on the theory, that the inorganic content of the hogs' tooth is considerably lower than in cattle and human teeth, and conversely, the organic content much higher. Thus when considerable amounts of organic content of the enamel structure in the hogs' tooth was digested or removed by the action of the enzyme, there was not sufficient body or strength in the remaining inorganic content of the enamel rods and matrix to hold the enamel rods essentially intact.

An experiment was carried out to determine an approximate relationship of the percentage composition of organic and inorganic content in human, cattle and hog teeth. The results were as follows:-

	Organic Percentage Composition (Approximate)	Inorganic Percentage Composition (Approximate)
1. Cattle	- 38.5%	- 61.5%
2. Hog	- 43.8%	- 57.2%
3. Human	- 32.2%	- 67.8%

2. The pepsin enzyme appears to have produced:

(a) pigmentation of the enamel

(b) digestion of the interod spaces in the enamel

(c) swelling of the dentinal tubules

(d) slight pigmentation of the dentin

B Acid Phase

Anterior teeth were completely coated with black compound except for a small "window" on the labial surface. The teeth were placed in a .5% solution of lactic acid, pH 3.5. Thymol crystals were added to control bacterial activity.

The observations were as follows:

1. A large percentage of the enamel structure of the crowns was lost, with a definite cupping out of the enamel over the window, with structure loss extending into the dentin matrix.

2. Remaining enamel structure possessed a brownish-grey opacity when held against the light.

3. The dentin structure below the window possessed a very dark brownish grey pigmentation, and was not of a hard texture but very rubbery and flexible.

4. Microscopically, the remaining enamel is quite homogeneous with very little definite structure remaining visible.

5. There was indefiniteness as to the outline of the dentinal tubules which had the appearance of a matrix slightly decalcified.

The possible conclusions are as follows:

1. The acid will completely decalcify and break down the enamel structure.

2. There was insufficient enamel structure remaining to establish the presence of cross-striation, i.e. the process of acid destruction had passed the phase of cross-striation of acid decalcification.

C Acid-Enzyme Phase:

Anterior teeth were completely coated with black compound except for a small "window" on the labial surface. The teeth were placed in a 30% solution of pepsin enzyme and a 1% solution of lactic acid, pH 3.5. Thymol crystals were added to control bacterial activity.

The observations were as follows:

1. There was considerable loss of structure over the window on the labial surface of the tooth, extending down to the dentin matrix.

2. The remaining enamel structure possessed a slight orangey-yellow pigmentation. (fig. 9, 11) along with evidence of cross-striation. (fig. 9)

3. The dentin showed definite signs of loss of structure, i.e. a homogeneous and an outward band of affected dentin in which the dentinal tubules appeared to be swollen and enlarged (fig. 9, 10)

4. There was also a definite orangey-brown pigmentation at the base of the window in the dentin matrix especially in the homogeneous structure of the dentin. (fig. 11)

The possible conclusions are the following:

1. The acid and the enzyme combine to form many phases characteristic of true caries.
   (a) cross-striation the enamel
   (b) yellowish pigmentation of the enamel
   (c) swelling of the dentinal tubules and a homogeneous appearance
   (d) orangey-brown pigmentation in the dentin.

ADDITIONAL EXPERIMENTS

EXPERIMENT - To Determine the Effect of Boiled Pepsin Enzyme on Protein Substance

Methodology - Two solutions of pepsin enzyme 40%, pH 4.5. One of the solutions was boiled for two or three minutes. Thymol crystals were added to control bacteria activity. Two whites of eggs were secured and one white of an egg was placed in each solution and stirred and allowed to stand for an hour. Then the nitric acid protein test was made for the presence of undigested protein (white of an egg) in the solutions.

Observations

1. After an hour there did not seem to be any presence of egg white remaining in the unboiled solution whereas there was strands of egg white remaining in the boiled solution.
2. The boiled solution gave a definite positive protein test whereas the unboiled solution was negative.

CONCLUSIONS

1. The boiled enzyme solution had not digested the protein content or egg white.
2. Boiling process inactivates the proteolytic digestive action of pepsin enzyme.

Experiment - To Determine the Effect of Boiled Pepsin Enzyme on Hog Teeth

Methodology -

Two solutions of 40% pepsin enzyme pH 4.5 were prepared, one solution of which was boiled for two to three minutes. Thymol crystals were added to control bacterial activity. Hog Teeth completely coated with black compound except for a window on the labial surface were placed in each solution for a period of ninety days.

Observations

1. The teeth immersed in the unboiled pepsin solution produced the same microscopical picture as those in similar previous experiments.

2. The teeth immersed in the boiled solution were not attacked and appeared to be microscopically unaffected by the solution.

Conclusions

1. Boiling process seems to inactivate the proteolytic digestive properties of pepsin enzyme.

2. It is the proteolytic properties of the enzyme that produce the characteristic changes in a tooth, and not the pH of the solution - because the boiled pepsin solution did not affect the teeth even though the pH of the solution remained constant as did the pH of the unboiled enzyme solution.

Experiment - To Determine the Ratio Composition of Organic to Inorganic Content in Human, Cattle and Hog Teeth.

Methodology

1. Samples of anterior teeth were radiographed for one and two second (regular film) before they were decalcified.

2. Samples of teeth were placed in bottles containing 400 cc of 4% nitric acid for a period of eight days. Weighings of the teeth were made to determine the approximate ratio of organic to inorganic content.

3. The teeth were radiographed again after decalcification.

Observations

1. Radiographic Interpretation of the relative degree of calcification in the teeth samples (decalcified before) showed a decrease in light opacity in following order, i.e., decrease in relative degree of calcification, sheep-calf-cow-hog.

2. Radiographic Interpretation after decalcification. The sections were completely decalcified by the acid, and the radiographs were completely opaque.

3. Results of experiment to determine percentage ratios are as follows..

(a) Human Teeth	-	Organic	= 32.2%
	-	Inorganic	= 67.8%
(b) Cow Teeth	-	Organic	= 38.5%
	-	Inorganic	= 61.5%
(c) Hog Teeth	-	Organic	= 43.8%
	-	Inorganic	= 57.2%

It is evident that the percentage of inorganic material content increases and the organic percentage content decreases respectively in the following order, hog, cow, human. The results of this experiment would suggest that hog teeth would be less resistant to proteolytic activity because of the highest content of organic material.

III EXPERIMENTS ON HUMAN TEETH

A Acid Phase

Human teeth were completely coated with black compound except for a small "window" on the labial surface. The teeth were placed in

(i) Lactic Acid 0.1%, pH 4.5.

(ii) Lactic Acid 0.1%, pH 4.5 which had first been fixed in 10% formaldehyde for thirty days.

(iii) Hydrochloric acid 0.5%, pH 4.5.

The teeth were left in the acid solutions for a period of approximately two months. Thymol crystals were added to control or inhibit bacterial activity.

The observations were as follows.

1. There was no apparent microscopical difference in appearance between the sections of teeth that had first been treated with formaldehyde and then lactic acid, and those teeth which were treated with lactic acid alone.

2. Hydrochloric acid is a very active acid and is much more rapid in its decalcifying action on human enamel than lactic acid, although, the microscopical picture produced is not unlike that produced by lactic acid.

3. The changes produced by the acids (lactic and hydrochloric) on human enamel and dentin are as follows.

   (i) The enamel in the "window" becomes chalky, opaque, losing translucency and polish.

   (ii) Cross-striations on enamel prisms (fig. 13)

   (iii) Destruction of interprismatic substance (fig. 12, 13)

   (iv) No evidence of pigmentation in the enamel

   (v) Hydrochloric acid in some of the sections produced a slight yellowish discoloration in the dentin (fig.19)

B Enzyme Phase

Human teeth have been subjected to the effects of the following enzymes for a period ranging from four to five months:-

1. Pepsin enzyme 30%, approximately pH 4.5
2. Papain enzyme 30%, approximately pH 4.5
3. Combined solutions of Pepsin 30% and Papain 30% enzymes, approximately pH 4.5
4. Boiled Pepsin enzyme, approximately pH 4.5

5. Sulfatase Enzyme 30%.

6. Trypsin Enzyme 10%, approximately pH 7.5 to 8.0

7. Amylase enzyme 10%, approximately pH 7.5 to 8.0

8. Ptyalin enzyme 10%, approximately pH 7.5 to 8.0

The results of these experiments cannot be recorded at this writing as the experimental teeth have not been subjected to the effects of the enzymes for a sufficient period of time as yet.

C Acid-Enzyme Phase:

Human teeth were coated with black compound except for a small "window" on the labial surface. The teeth were placed in a 30% pepsin enzyme solution - approximately pH 4.5, combined with a 0.1% lactic acid solution - approximately pH 4.5, for a period of two months and then the teeth were removed and placed in a 30% pepsin enzyme solution for four months.

Many changes were produced artificially characteristic of caries of the enamel.

1. Pigmentation. In the sections in which the process is entirely in the enamel and had not reached the dento-enamel junction, there was a darkly pigmented (orangey-yellow) band in advance of the carious lesion (fig. 14, 16). This band is more darkly pigmented than the pigmentation found in the enamel prisms. On the border of the pigmented band are little orangey-brown pigmented "icicles" projecting into the adjacent partially broken down enamel matrix. Thus it appears that the decalcifying - proteolytic process, initiated by the lactic acid and pepsin enzyme, appears to work down between the rods or along the enamel prism sheathes in advance of the same process working down through the centre of each enamel prism (fig. 15, 17, 18, 21)

2. Pigmentation of the enamel prisms. The pigment produced was a definite orangey-brown and was confined only to the area below the "window" (fig. 14, 16, 22)

3. Transverse Striation. These are cross-striae seen on the enamel prisms. The striae appear to be double lines (fig. 14, 15, 17, 18).

4. Destruction of the interprismatic substance with minute spaces between the enamel rods (fig. 15, 17, 18, 21). This may be due to a swelling of the enamel sheathes, or a complete digestion of the interod substance. The changes produced artificially that are characteristic of certain changes in the dentin in caries are the following:

1. A yellowish-orange pigmentation of the dentin below and at the dento-enamel junction (fig. 22)

2. Dentin shrinkage at the dento-enamel junction beneath the carious lesion in the enamel (fig. 22)

3. Transparent dentin underneath the zone of yellow pigmentation (fig. 20, 22).

Other acids, namely succinic, tartaric, phosphoric, formic, pyruvic, propionic, all work successfully with pepsin enzyme solutions to produce effects on enamel and dentin like those produced by lactic acid and pepsin enzyme.

The significant conclusions that can be drawn from the observations of experiments on the phases of caries in human teeth are the following:

1. Various acids have been acclaimed by researchers in different parts of the world as the specific acid responsible for the acid - decalcification phase in the dental caries process. Experimentation shows that many acids will produce decalcification of enamel, but certain acids are definitely more active than others. It is quite probable that it is the relative p^H that is more important than the specificity of any particular acid in the acid phase of caries. The emphasis placed on the role of acid in the production of dental caries has undoubtedly served to obscure the broader and more fundamental mechanism concerned in the caries production. The evidence to date shows that the acid attack on enamel does not produce the total microscopical picture of enamel caries.

2. Proteolytic pepsin enzyme attacks the organic content of teeth and the changes produced characteristic of caries are more pronounced when activated by acid action.

3. A combined acid-enzyme attack produces many of the changes that are produced in a frontal caries process. Thus it seems evident that an artificial caries - producing mechanism can be set up in a test tube without the aid of bacteria. However, there are many features of the proteolytic phase of dental caries yet to be clearified.

Results show that "experimental solutions" with weaker concentration in reference to the acid content of the acid-enzyme combined solution, which teeth are subjected to for periods ranging up to eight months (thus simulating the period for the development of a natural caries lesion) produces an artificial caries to a much clearer and more pronounced degree, and with less total loss or disintegration of the affected tooth structure than these "experimental solutions" used in similar previous experiments that were of stronger concentrations and which teeth were subjected to for shorter two to three month periods. Experiments were set up to investigate the possible effects of alkalies on human tooth structure.

The effects of 5% sodium hydroxide solution and a combined solution of sodium hydroxide and an enzyme solution were proved to be negative, thus eliminating the possibility of an alkaline caries.

Other experiments now in progress, and to be started presently with the objectives in mind are outlined as follows:

1. A further investigation of the protein breakdown of enamel matrix using other enzymes, or a series of enzymes to attempt a "chain" breakdown of the protein content of enamel.

2. To combine these experiments mentioned above with the acid phase of caries in an attempt to improve on the artificial acid-enzyme "caries-producing mechanism".

3. To test fluorine treated teeth against the "caries producing solutions" in an attempt to appraise and determine the value of fluorine as a preventive measure to dental caries.

APPENDIX "R"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March 1949

Subject: To study the effects of decreased barometric pressure on the oral tissues.

Grantee: R.C.D.C.

Project No.: DR 6 Amount of Grant: Nil

SUMMARY OF WORK

Method of Study:

1. Three hundred and fifty three flight cadets of the RCAF were dentally examined and oral conditions were recorded.

2. They were subjected to runs in the decompression chamber during routine air crew tests.

3. All subjects displaying dental symptoms during decompression were interviewed and re-examined.

Observations:

1. The incidence of aerodontalgia in a group of 353 flight cadets is 1.7%.

2. Not one of 86 teeth with pulp exposure or near exposure caused pain under decompression.

3. Four cases experiencing dental pain while descending in the chamber were attributed to blockage of the maxillary sinus.

4. Two cases of dental pain under decompression occurred in recently filled sensitive teeth without a cavity lining.

5. The possibility of pulpal gas bubbles under lowered pressure as a factor resulting in the exacerbation of a chronic condition is considered.

Conclusion:

1. There is little doubt but what many individuals experiencing maxillary sinus blockage during descent interpret the pain as of dental origin.

2. The thermal, chemical or traumatic shock to the pulp, accompanying cavity preparation and the insertion of a filling, may in some cases cause pain under decompression. Care in cavity preparation and the use of insulating materials in sensitive or deep cavities are suggested.

APPENDIX "H"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

March 1949

Subject: To study the effects of decreased barometric pressure on the oral tissues.

Grantee: R.C.D.C.

Project
No.: DR 6 Amount of Grant: Nil

SUMMARY OF WORK

Method of Study:

1. Three hundred and fifty three flight cadets of the RCAF were dentally examined and oral conditions were recorded.

2. They were subjected to runs in the decompression chamber during routine air crew tests.

3. All subjects displaying dental symptoms during decompression were interviewed and re-examined.

Observations:

1. The incidence of aerodontalgia in a group of 353 flight cadets is 1.7%.

2. Not one of 65 teeth with pulp exposure or near exposure caused pain under decompression.

3. Four cases experiencing dental pain while descending in the chamber were attributed to blockage of the maxillary sinus.

4. Two cases of dental pain under decompression occurred in recently filled sensitive teeth without a cavity lining.

5. The possibility of pulpal gas bubbles under lowered pressure as a factor resulting in the exacerbation of a chronic condition is considered.

Conclusion:

1. There is little doubt but what many individuals experiencing maxillary sinus blockage during descent interpret the pain as of dental origin.

2. The thermal, chemical or traumatic shock to the pulp, accompanying cavity preparation and the insertion of a filling, may in some cases cause pain under decompression. Care in cavity preparation and the use of insulating materials in sensitive or deep cavities are suggested.

3. The expansion of gases in putrescent pulps etc., may be an activating factor in exciting a chronic condition.

4. No changes in the accepted methods of treatment of dental problems are suggested. A thorough and frequent dental examination accompanied by good dentistry would seem to eliminate many of the problems in the field of aviation dentistry.

E. M. Wansbrough (Colonel)
Director General Dental Services.

APPENDIX "S"

The Subcommittee consisting of Dr. J.K.W. Ferguson, Dr. M. H. Garvin, Dr. A. W. Ham and Mr. S. J. Cook, appointed to study the question of reprints and publications of the Associate Committee on Dentistry reports as follows:

1. It is moved that the following minutes relating to the publication of research assisted by the Associate Committee on Dental Research be rescinded: Executive 5:4(iv); Committee proceedings 1:6; 6:6; 8:30;

2. It is moved that the following procedures be adopted:

(i) Grantees in their periodic reports shall inform the Committee of the portions of their work which are to be submitted to some Journal or publisher for publication.

(ii) Acknowledgment of assistance by the Associate Committee on Dental Research shall appear on the publication. Whenever consistent with the policy of the journal or publication the acknowledgment shall take the form of a footnote saying:" Assisted by a grant from the Associate Committee on Dental Research of the National Research Council of Canada".

(iii) When such publications appear the grantee shall inform the Secretary of the Associate Committee on Dental Research giving the author or authors, title and reference.

(iv) The Secretary of the Associate Committee on Dental Research when notified of a publication on work assisted by the Associate Committee on Dental Research shall assign a number to the publication and shall list this number together with the author, title and reference as an appendix to the minutes of the meeting of the Associate Committee on Dental Research.

(v) The grantee shall supply, when they become available, fifty reprints of each publication for the use of the National Research Council.

(vi) One reprint of each publication shall be distributed to each member of the Associate Committee on Dental Research.

4 March, 1949.

APPENDIX "B"

INITIAL DISTRIBUTION

		Term to Expire
* 1.	Dr. R. G. Ellis, Chairman	31 March, 1951
2.	President C. J. Mackenzie (ex officio)	--
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